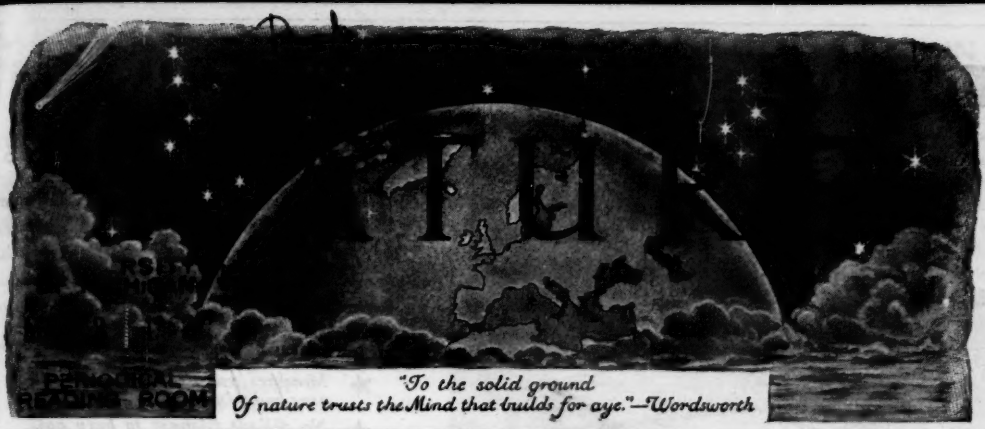

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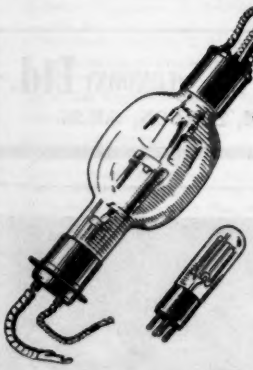

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NATURE

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NATIONAL PARKS IN BRITAIN

THE second annual report of the National Parks Commission*, which is the first to cover a complete year, appeared shortly after the disappointing debate on the adjournment in the House of Commons on December 6, and should be read in the light of the refusal of the Parliamentary Secretary to the Ministry of Housing and Local Government to give the assurance sought by Dr. Stross and Mr. A. Greenwood in opening the debate. Mr. Marples ignored the point about financial restrictions and declined to reopen the question of joint administration or the appointment of planning officers, and merely appealed to members to give the Joint Boards a chance to prove themselves. The Commission's report attaches special importance to this principle that the planning officer of a Joint Planning Board should be a whole-time servant of the board and independent of any of the component local authorities. The Commission had hoped that the orders appointing the Joint Boards for the Peak and Lake District Parks would have provided for this, and it has since invited the chairman of each Board respectively to give earnest consideration to the principle, which it regards as having an important bearing on the administration of the parks according to the full intentions of the National Parks Act.

Where a park comprises territory from several planning authorities, a Joint Planning Board is the normal instrument which Parliament has prescribed in the National Parks Act for the administration of a national park. The Commission declares its own intention to work whole-heartedly for the success of the administrative method which has been adopted in spite of the recommendations of the Hobhouse Committee, and it looks forward to the equally loyal co-operation of the local authorities concerned. It is rightly observed that the whole conception of national parks now depends upon the competence and efficiency and imagination of the Joint Planning Boards. What might well be added, particularly in view of the adjournment debate, is that the Government also has a duty to see that the Joint Planning Boards have a reasonable opportunity of discharging their responsibilities. The policy of non-intervention seriously threatens to frustrate the fundamental purpose of the Act as passed by Parliament. It is not simply that the National Parks Commission is virtually deprived of all power by the new conditions, and the local authorities are made primarily responsible for working the Act; what is more important, the planning staffs are subject to the strains of a divided loyalty, which in itself could make effective planning or administration of a 'national' as opposed to a 'local authority' park impossible, and the local authorities are subjected to a financial strain which some at least of them, for example, Westmorland, have scanty resources to meet. Beyond this it is unfair and absurd to place on local authorities the task of resisting the encroachments of government departments and

* National Parks and Access to the Countryside Act, 1949. Second Report of the National Parks Commission for the Year ending 30th September 1951. Pp. iv+24. (London: H.M. Stationery Office, 1951.) 2s. net.

statutory undertakers, which represent the greatest threat to the national parks; that task must be undertaken by a national body or not at all.

Besides the four national parks noted in this report as designated and confirmed, a fifth, the Pembrokeshire Coast National Park, has been designated, and consultations have already begun with fifteen local authorities regarding the North York Moors, the proposed boundary for which area follows closely the line suggested by the Hobhouse Committee. Proposals for the Pennine Way were approved by the Minister in July, and in notifying this decision to local authorities the Minister expressed the hope that the whole of the route would be available to the public by Easter 1952. The Commission emphasizes that this, the first of the long-distance routes, is intended to be an entirely informal cross-country route similar to the rough mountain tracks to be found in the Lake District and North Wales. It will be a strenuous high-level walk through predominantly wild country and is intended for walkers of experience who are able to endure rough going. This is indeed one of the main attractions of the Pennine Way; but the Commissioners believe that the route which has been approved will not present undue difficulty to those who are prepared to spend several days walking along it.

At the request of the Commission, Mr. R. M. Lockley has surveyed a route along the Pembrokeshire coast, and the Cornwall County Council one of the northern coast of Cornwall and around the Land's End peninsula. The Cornwall County Council is to survey the remaining coast of Cornwall, and the Devon, Somerset, and Dorset County Councils are making surveys of their respective coast-lines. Detailed field surveys are also being made of Offa's Dyke, the South Downs to Salisbury Plain, the Pilgrim's Way, the Chilterns to the Devon coast and the Thames Riverside Walk. These long-distance walks are thus based upon some strong physical or historical feature, and all of them were recommended in the report of the Committee on Footpaths and Access to the Countryside.

This is perhaps the most encouraging section of the report. In the following section, which describes the steps taken to prepare and disseminate a country code of conduct, the Commission again records frustration. It regards publication of the country code as a core around which will grow a body of information about the countryside. As knowledge spreads there should be much less of the damage done often through sheer thoughtlessness by well-intentioned people. By all these means the Commission hopes there will be a deepening respect between countrymen and townsmen. Nevertheless, it has been unable to obtain authority for the expenditure of £350 on the production of a leaflet for free distribution.

The impression that the Commission is by no means as autonomous as was intended by Parliament is confirmed by the observations in the next section of the report, relating to the advisory activities of the Commission in regard to development. Under Section 85 of the Act, the Commission is charged with very wide responsibilities for giving advice on questions which may affect the natural beauty of any part of the countryside; but to avoid dissipating its energies in its early years, the Commission has been reluctant to go outside the national parks themselves and has tried to consider the problems put to it in the order of their importance. The range of those problems is illustrated in appendixes to the report, dealing with overhead electricity line proposals in Martindale and for the Malvern Hills, the North Wales hydro-electric proposals, and some examples of mineral workings, Service land requirements and afforestation affecting national park areas.

It is clear enough from the views expressed by the Commission in these appendixes that the gravest threats to the national parks of Britain and to the countryside generally arise from government departments, and of the particular threats discussed in this report the proposed hydro-electric schemes in North Wales of the British Electricity Authority are the most serious. Already the Authority has applied to Parliament for leave to introduce a Bill for carrying out a scheme which includes four main proposals directly affecting the Snowdonia National Park. If carried out, these four schemes would, in the view of the National Parks Commission, so dominate the landscape of Snowdonia that its essentially wild character would to a large extent be destroyed. Before proceeding with the Bill, the Authority requires the consent of the Minister of Fuel and Power under the Electricity Acts. This has already been given in respect of the Blaenau Festiniog scheme and the extensions to the existing schemes at Dolgarrog. The Minister, however, has undertaken to consult the Minister of Housing and Local Government before consenting to the promotion of the Bill, and the Commission accordingly took an opportunity of acquainting the latter Minister with its views upon the proposals.

Those views have no doubt been made known to Mr. Harold Macmillan; but nevertheless the adjournment debate failed to provide evidence that careful and firm administration will be forthcoming. Good planners may be scarce; but the number of chief planners required for independent administration under the Joint Planning Boards is so small as to make that plea as ridiculous as the parsimony limiting the financial operations of the Commission. Little confidence can at the moment be felt that the Commission's representations by themselves are likely to be effective. If, in fact, the Snowdonia National Park is saved, it appears more likely to be because the economic advantages of these schemes are too slight to be worth pressing, particularly if local anxiety over the effect on the tourist industry outweighs the hopes for additional employment. There is no indication that the decisive factor is likely to be the principle which is laid down in the Dower report and which is again quoted by the Commission: "The fundamental decision made where a given area is established as a National Park is that within it two purposes, out of the numerous possible purposes for which the land might be used and developed, shall thereafter stand supreme: all other use, though by

no means excluded, being so limited and controlled as to harmonise with the two dominants. These are (*a*) that the characteristic beauty of the landscape should be preserved and that (*b*) the visiting public should have ample access and facilities within it for open air recreation and the enjoyment of beauty".

The report quotes this passage in connexion with an attempt to remove some widespread misconceptions as to the consequences of creating national parks which have been revealed, particularly in the inquiry regarding the Peak District National Park. Inclusion of land in a national park, the Commission emphasizes, effects no change whatsoever in ownership of land, and there is no difference, as regards access, between land inside a national park and land anywhere else, although it is hoped that more facilities for access will be available inside a park. Cultivated land is expressly excluded from the access provisions of the Act, nor is there any reason to fear that inclusion of land in a national park involves stagnation of housing or industrial development. It does ensure that when fresh decisions on the use of land have to be taken, whether for mineral development, training or other purposes, special consideration will be given to amenity and recreational value; and the fact that it is expected that a higher standard of planning will obtain inside a park than in less favoured areas is one important reason why the various parks should have their own independent planning officers.

Unless, however, in such areas those claims of amenity and recreation do, in fact, stand supreme in the event of a clash with other users, there can be little real meaning in the conception of national parks. That is the reason for viewing with such concern the North Wales hydro-electric proposals and the overhead line proposal in the Malvern Hills. Since the report was issued, Mr. Justice Valsey, in the Chancery Division, has dismissed the claim of the National Trust which sought to restrain the Midlands Electricity Board from erecting an overhead cable on a 500-yard stretch of the Malvern Hills. He held that the effect on the view from Midsummer Hill was infinitesimal and that the restrictive covenants did not prohibit the erection of poles.

This judgment has undoubtedly seriously weakened the defences of amenity and natural beauty against expediency. In the first place, the financial resources of bodies like the National Trust and the Councils for the Preservation of Rural England and Wales are already slender and unable to stand the costs of many such actions, however much it may be their duty or desire to contest them. The awarding of costs to the defendants must handicap the National Trust in future, and the National Parks Commission has already had sufficient experience of its advice being rejected to feel diffident about its own ability to keep even the designated park areas inviolate. Moreover, the judgment has raised doubts as to the validity of restrictive covenants in general, and it has already been suggested that further legislation is required to protect more effectively the natural beauty of properties owned or held under covenant by the National Trust.

The argument for further reference to Parliament is substantiated by this report of the National Parks Commission. The menace to the parks and to amenity everywhere comes particularly from government departments and quasi-government boards armed with compulsory powers. They can only be restrained by the Minister, or possibly by an interdepartmental committee at Cabinet level where rival claims can be thrashed out and which possesses the authority to ensure that departments do not judge their own cause. Unless Parliament intervenes and insists on the observance of this fundamental principle of justice and of sound administration, there is small hope of the establishment of any effective national parks or nature reserves in Britain, or of the safeguarding of amenity even to the limited extent hitherto possible through the National Trust. Pledges were given to Parliament when the Town and Country Planning Act as well as the National Parks Act and the earlier National Trust Acts were passed, and upon Parliamentary vigilance depends the best hopes of effective action before it is too late. The surveys which are now being completed by the counties and the plans being submitted to the Minister of Housing and Local Government may well help to secure the necessary action. The report of the National Parks Commission demonstrates the existence of a large amount of goodwill not only among individuals and the local authorities, but also in the departments and public bodies whose plans are most liable to endanger amenity. The basis for co-operation undoubtedly exists. It is for the Minister to see that it is made effective at the highest level, and that there is an impartial body of high repute and Government standing, able to ensure that all sides of any particular proposal are fully considered and the possibilities of multiple use by different interests examined; and further that no decisions are taken unilaterally by any department or public body without regard to the widest national interests that may be involved.

THE STORY OF THE CHEMICAL ELEMENTS

Man and the Chemical Elements

From Stone-Age Hearth to the Cyclotron. By Dr. J. Newton Friend. Pp. ix+354+4 plates. (London: Charles Griffin and Co., Ltd., 1951.) 27*s*. 6*d*. net.

THE idea of the existence in Nature of a limited number of simple bodies from which an indefinite number of other more complex bodies can be built up may be traced back into the misty regions of prehistory. According to the later Aristotelian philosophy, the four elements of Empedocles—the still familiar earth, air, fire and water—were based in turn upon four fundamental qualities or essences of bodies, namely, the hot, cold, dry and wet. The underlying conception, going back in time far beyond the Greek philosophers, may be traced in ancient India, Egypt and China. As Rodwell wrote in 1874, it is "one of those crude physical theories which is enunciated and accepted by races the most diverse

in character, country, faith, destiny. There is great oneness in the human mind in the matter of broad principles in crude cosmical ideas".

In the last analysis this earliest theory of physical science appears to have originated in a primitive mode of thinking based upon a distinction between opposites or contraries. Aristotle's four qualities themselves consisted of two pairs of opposites; and throughout a millennium of alchemy a peculiar significance was attached to the two opposed elements, fire and water. In another guise these opposed elements reappeared in the sulphur–mercury theory of metals; and sulphur descended into a still later age under the name of phlogiston. In the words of Tenney L. Davis, "the doctrine of the two contraries, with only superficial modifications, dominated the science of chemistry until the time of Lavoisier". May we not even draw upon that "great oneness in the human mind" in order to find a contemporary home for this ancient doctrine in the imagined sub-atomic world of the proton and electron?

Coming now to Dr. Friend's book, we find that it is rich in the lore and history of alchemy and early chemistry, in so far as the discovery and utilization of the elements are concerned. Further, the author shows briefly and in simple language how the conception of a chemical element developed from primitive ideas through the work and views of Boyle, Lavoisier, Dalton, Berzelius, Mendeléeff and others; until finally, in the last phase of a long story reaching from the stone-age hearth to the cyclotron, he outlines the spectacular advances of the present century, linked with such names as Rutherford, Moseley, Curie, Cockcroft and Walton. He expresses the current conception of a chemical element in the following words: a substance possessing one atomic number and one only.

Of the ninety-eight elements now recognized, only nine were known to man before the Christian era: these were the metals, gold, silver, copper, lead, tin, iron and quicksilver; and the non-metals, carbon and sulphur. No specific discoverer can be assigned to any of these elements. Curiously enough (for here we behold an element of incongruity), it would seem from a scrutiny of the available data that the credit for the first specific discovery of a chemical element must be given to one Hennig Brand, a merchant of Hamburg, who isolated phosphorus from urine in 1669. There are many fascinating stories bound up with later discoveries of elements, and these will be found interspersed in Dr. Friend's systematic survey, which extends from the permanent and the inert gases, through other non-metals and various groups of metals, to the radioelements and the actinide series.

The general character of the book may be illustrated by referring to the description of silver, 'the queen of the metals'. A note on its natural sources is followed by an account of some famous silver mines. Here we find the drama of the Salcedo mine, a sad tale of old Peru culminating in the tragic end of Salcedo and the destruction of the mine by his revengeful Indian mother-in-law. The associations of silver with the Egyptians, with Holy Writ, with the Romans, and (very briefly) with the alchemists, together with sections on Sheffield plate, methods of silvering, and silver coins, provide much further interesting material. At this point we step unexpectedly into that former resort of Olympians, Joe Lyndon's nineteenth-century Minerva Tavern in Peck Lane, Birmingham. "At this tavern the 'cups' or tankards were of solid silver and the property of the regular patrons. None of inferior metal was permitted. Uniform in size and shape the name of the owner was legibly engraved across the bottom of the 'cup' in such a way that when hung in front of a top shelf in the bar it could be distinctly read. There were 37 such cups. In addition there was another silver cup that held three pints; it was known as the 'Fine Slapper' because if anyone committed a breach of good manners he was liable to a fine of 'a slapper of ale', that is, three pints."

Written in a pleasantly discursive vein, the book has a sound scientific basis and is well documented and indexed. It is a mine of information on a variety of unusual subjects, as diverse as alchemical symbols and atomic clocks, or mottled teeth and meteorites. At the same time it contains a wealth of apposite chemistry, history, lore and anecdote, presented in a manner likely to appeal equally to scientific worker and layman.

John Read

MOSQUITOES AND MALARIA

Mosquito Behaviour in relation to Malaria Transmission and Control in the Tropics

By Dr. R. C. Muirhead-Thomson. Pp. viii+219+16 plates. (London: Edward Arnold and Co., 1951.) 30*s*. net.

THIS is a good book on what may be termed 'breeding biology' by a well-known entomologist who himself is widely known for his original work in this direction. It is a very modern, exact entomology, which has been developed only during recent years. It delves deeply, so to speak, into the private lives and general behaviour of those anopheline mosquitoes which are responsible for the transmission of malaria in the tropics, in an attempt to gauge the relation of the distribution of breeding places and the insects' activities to modern methods of control. Recent developments in the use of residual insecticides against adult mosquitoes are based upon minute observations made upon their habits and breeding behaviour.

The first part of the book is concerned with the movements of mosquitoes in relation to mating, breeding and resting; the second with the nature and selection of breeding places and the part played by simple physical and chemical factors in determining the behaviour of the female mosquito and its larval stages.

This account is based upon additions to our knowledge of *Anopheles* which have been made in the past fifteen years. The beginning of this period marked a change in outlook by the discovery of the existence of different races of *Anopheles maculipennis* in Europe and their relation to the problem of anophelism without malaria, and this type of work has now extended to the tropics of Asia and Africa, resulting in a train of new ideas about the behaviour of *Anopheles* in the field. This period, too, has been marked by increasing realization of the part played by temperature, humidity and other climatic conditions on insects in general, but on anophelines in particular. There has also been an increasing appreciation of the fact that, as *Anopheles* are very active at night, most of their activities can only be adequately studied during that period. All this dates from about 1938.

The course of research upon mosquito behaviour and malaria control was greatly influenced by the

Second World War, when it became of vital importance to protect large bodies of troops from malarial infection in the tropics. There has also been a revival and intensification of controlling *Anopheles* by direct attack against the adult mosquito, as distinct from waging war upon the larvæ and breeding-places.

Despite the universal acclamation of DDT, it is now known that the most impressive method, so far employed, of indicating its long-sustained lethal effects upon adult mosquitoes is based upon erroneous interpretation of the mosquitoes' movements. It must not be thought that straightforward natural history is entirely outmoded. The remarkable association between *A. melas* breeding-stands of *Avicennia* mangrove in Freetown estuary (Sierra Leone) is a case in point. This, then, is a summary discussed in some twelve chapters.

Upon all aspects there is a wealth of information which tends to make the text of this book heavy reading; but it provides good meat for the scientific entomologist, and from this point of view the author is to be congratulated. PHILIP MANSON-BAHR

SCIENCE AND SOCIETY

The New Society

By Edward Hallett Carr. Pp. vii+119. (London: Macmillan and Co., Ltd., 1951.) 7*s*. 6*d*. net.

New Hopes for a Changing World

By Bertrand Russell. Pp. 218. (London: George Allen and Unwin, Ltd., 1951.) 9*s*. 6*d*. net.

BESIDES being based on broadcast lectures, these two books have much in common. Both analyse the problems of contemporary society in the light of the new powers with which science has endowed mankind and endeavour to estimate the prospects of survival. To a limited extent they attempt also to indicate the most hopeful means of ensuring the survival of mankind, and in that attempt they diverge more than in their analysis, which agrees in many respects. The divergence is due chiefly perhaps to Prof. E. H. Carr's inability to share Earl Russell's faith in the capacity of reason to transform human nature through the processes of education, though the difference may be one mainly of the rate of change. Prof. Carr does not deny the possibility of such change nor does Earl Russell claim it as probable rather than possible.

The real differences between the two books are more subtle—of approach and style rather than substance. One author surveys the situation as a philosopher: always events and problems are considered *sub specie æternitatis*, and the serene faith in the capacity of man to solve these problems and overcome his difficulties, if only he will make the effort, which shines out from the pages of "New Hopes for a Changing World", is expressed with Earl Russell's usual charm of style, and frequently flashes with wit, sardonic humour or gentle irony. The historical approach of Prof. Carr is no less stimulating or penetrating, if less polished in style. He, too, believes reason to be on the side of the angels, if he deprecates exaggerated claims. His gaze also is on the future, rather than on the past, though he echoes too often Tocqueville's metaphor of the ruins on the receding shore. The scientific worker in particular will find his analysis at least as attractive and suggestive as that of Earl Russell, especially in his conception of progress and of freedom.

Hope, rather than confidence, is the keynote of Earl Russell's book. He looks at the darkest, most intimidating features of the world to-day and is undismayed, and his belief that man should not be afraid or cringe before external events which it is in the power of man to control is a challenge to man's self-respect. He seeks to encourage all the creative impulses of man, to liberate men, not only from conscious fears but also from the old primeval terrors or inhibitions that we brought with us out of the jungle, and to do this in a way that brings happiness equally to ourselves and to others.

Earl Russell distinguishes three kinds of conflict in which man is engaged: with Nature, with his fellow men, and with himself; and in each of these the aim should be to achieve harmony. Of the first he reminds us that victory in it is essential to survival, and in the first part of his book he brings out the real issues that confront us to-day in considering man's control over Nature: the supreme importance of the wise use or husbanding of our resources and of dealing with the population question. These short incisive chapters dispose of the facile optimism which is too prevalent and leave no reader in any doubt as to the consequences of failure to act wisely on the knowledge already at our disposal.

That part of Earl Russell's book could be described equally as an essay upon the limits of science and technology and on the relation of power to knowledge. The latter title could also be applied to the second part, in which he considers those problems of organization which are involved in the relations of men with one another, whether within industry and the nation, between nations or races or at the stage of world government. Here on the positive side Earl Russell is less convincing than when he deals devastating thrusts at human follies like the racial intolerance of the South African Government or the extremes to which the security measures have been carried in the United States. His sane and sensible comments bring out the dangers which current ideologies as well as nationalism present to mankind and the imperative need to clear our minds and our human relations of such prejudices as well as of obsolete practices. That argument is developed more fully in the final part of his book, where he displays, briefly but attractively, his theory of education with its repudiation of the idea that man's nature cannot change, and develops a picture of life free from fear. It is not easy to do justice to that vision, but though he has clearly retained certain values such as that of courage, one is left with the impression that his mind and heart are at odds, that his rigorous scientific attitude has left the philosopher with few ideals or values with which to build the happy life he depicts and to supply the cohesion in the structure of the new society he foresees.

Prof. Carr's argument seems to halt at much the same point. He traces the passage of mankind from competition to planned economy, which he argues is the only alternative to annihilation in war, and endeavours to set forth what is involved in such an economy when social welfare has replaced the economic whip, and what he rightly describes as mass democracy takes the place of individualism. Here his analysis brings out clearly much that is required if we are to succeed, as he believes is possible, in reconciling democratic freedom with socialism; but he is shrewder at the diagnosis of weaknesses than at the exposition of remedies, and his belief in

reason is not fortified with the same serene philosophy as Russell's.

Notably is this true when Prof. Carr writes of the international scene and of the road to freedom. He stimulates thought. He stresses some, but not all, of the factors that must be taken into account if we are to build a new world. He is no iconoclast and believes that it is possible to build fresh achievements on those of the nineteenth century; but his idea of the limits and potentialities of science and technology is neither as clear nor as comprehensive as that of Earl Russell, and he does not really face the contradictions between individualism, social responsibility and political or economic power of which he is well aware and which must be resolved in formulating either a social philosophy or a science of politics. One looks again for some indication as to what is to be the cement that will hold together the fabric of the new society.

For all these limitations, both books are to be read and pondered. They give us no facile pattern of a new world or society; but they could contribute to the critical insight, to the revision of judgments, and to the weighing of values which are part of the creative thought which must precede the shaping and making of a new world. They challenge the prevailing timidity, conservatism and restrictionism for which Prof. Carr in particular pillories contemporary Britain; and in sombre days they summon men and women to be worthy of their heritage of the past and to face the future with confidence, uninhibited and unafraid.

R. Brightman

NEW MONOGRAPHS ON PHYSICS

The Earth's Magnetism

By Prof. Sydney Chapman. (Methuen's Monographs on Physical Subjects.) Second edition, revised and reset. Pp. xi+128. (London: Methuen and Co., Ltd.; New York: John Wiley and Sons, Inc., 1951.) 6*s*. net.

Semi-Conductors

By D. A. Wright. (Methuen's Monographs on Physical Subjects.) Pp. viii+130. (London: Methuen and Co., Ltd.; New York: John Wiley and Sons, Inc., 1950.) 7*s*. 6*d*. net.

Photons and Electrons

By K. H. Spring. (Methuen's Monographs on Physical Subjects.) Pp. vii+108. (London: Methuen and Co., Ltd.; New York: John Wiley and Sons, Inc., 1950.) 7*s*. 6*d*. net.

An Introduction to Electron Optics

By Dr. L. Jacob. (Methuen's Monographs on Physical Subjects.) Pp. x+150. (London: Methuen and Co., Ltd.; New York: John Wiley and Sons, Inc., 1951.) 8*s*. 6*d*. net.

Introduction to Servomechanisms

By Dr. A. Porter. (Methuen's Monographs on Physical Subjects.) Pp. vii+154. (London: Methuen and Co., Ltd.; New York: John Wiley and Sons, Inc., 1950.) 7*s*. 6*d*. net.

THE series of "Methuen's Monographs on Physical Subjects" is a boon to honours and postgraduate students and to many research workers in physics and allied branches of science. The monographs provide an up-to-date introduction to modern developments and new techniques. In this they supplement and anticipate the text-books. Their authors are either engaged in research on the subjects about which they write, or are highly skilled in the use of the methods and techniques which they describe. The reader is expected to have had a good scientific training though not necessarily in the particular branch of physics discussed. The language used is technical and mathematical.

The monographs under review are five recent additions to the series. One only is not new: this, "The Earth's Magnetism", by Prof. Sydney Chapman, is a revised and completely reset edition. Prof. Chapman, by avoiding the mathematical developments of the subject and such cognate topics as radio research, itself worthy of a monograph, has managed to give a brief but broad account of the earth's magnetic field and its changes. The new diagrams and the magnetic charts for 1945 will be found particularly useful. In spite of the detailed knowledge that is now available concerning the earth's magnetism, it would appear that its origin is still a matter of uncertainty.

Three monographs deal with phenomena connected with electrons. "Semi-Conductors", by D. A. Wright, is concerned mainly with the density and flow of electrons in metals, crystals and semi-conductors and with the emission of electrons from these substances. The treatment is largely descriptive and deals with work up to about the middle of 1949. For example, the transistor is given barely four pages. "Photons and Electrons", by K. H. Spring, gives a brief account of the main ways in which electrons interact with radiation. The photoelectric effect, the Compton effect, the production of X-rays, the formation of electron pairs and certain aspects of cosmic-ray phenomena are separately discussed. Both monographs suffer from minor errors in units and mathematical expressions.

The fourth monograph, "Electron Optics", by Dr. L. Jacob, is an attempt to state the principal laws governing the motion of charged particles through electric and magnetic fields. The close analogy between light optics and electron optics is stressed, and it is assumed that the reader is familiar with simple optical devices. Though published in 1951, the foreword to the monograph is by the late Sir Clifford C. Paterson and is dated March 1947. The otherwise good bibliography to the monograph is marred by the unorthodox abbreviations used for the titles of the journals quoted. The abbreviations are difficult to interpret and no key to them is provided.

The last of the five monographs, that on servomechanisms, by Dr. A. Porter, is rather different in character from the other four, in that, first, it is based on a course of lectures given by the author while professor of instrument technology at the Military College of Science, Shrivenham, to army officer students studying engineering physics; and, second, it is scarcely likely that physics students, unless and until they enter industry, will need to have any knowledge of the subject of servomechanisms. Though there are some notes on non-linear problems, it is mainly linear servo systems which are dealt with, and the steady- and transient-state behaviours of these are considered. The Laplace transformation is not used. The aim is to lay emphasis on the physical principles and to avoid mathematical complication. Nevertheless, the physics student will find the going rather difficult, and perhaps in this connexion the title "Introduction" is misleading.

S. Weintroub

The Annual of the British School at Athens

No. 46, 1951: Papers presented to Prof. Alan Wace to commemorate Fifty Years of Work in Archæology. Pp. vii+252+25 plates. (London: British School at Athens, 1951.) 63*s.* net.

SEVENTEEN British and thirteen foreign scholars have contributed papers to a volume which appropriately and deservedly commemorates the work of a colleague who during fifty years has laboured in the field of archæology with outstanding success. The papers, many of them illustrated by plates, cover many different branches of archæological study and need for reviewer a scholar with knowledge and interests as wide as those of Prof. Alan Wace himself. They range from a survey of preclassical Greece by C. W. Blegen to notes by D. Talbot Rice on post-Byzantine figured silks and R. M. Dawkins on modern Greek folktales. Prof. Dawkins's paper and a few others—Sir Ellis Minns's on a Greek manuscript in the library of Pembroke College, Cambridge, and Miss H. L. Lorimer's on stars and constellations in Homer and Hesiod—fall outside the normal scope of archæology, but they are as fitting a tribute to the broad interests of the scholar in whose honour they are written as those on archæological subjects which fill most of the volume. The width and variety of Prof. Wace's learning are recognized in the graceful Greek elegiacs with which D. S. Robertson dedicates the volume, and demonstrated by the impressive bibliography of his published papers and reviews with which Helen Waterhouse concludes it.

The book is well produced and indexed. Thus does the British School at Athens do honour to one who was closely associated with it, first as student then as director, for more than twenty years at the beginning of the century, and who has since then done so much in other spheres to promote archæological work.

A Short History of Radio-Activity

By Dr. T. W. Chalmers. Pp. 78. (London: *The Engineer*, 1951.) 8*s.* 6*d.*

SEVERAL series of articles dealing with chemical and physical developments during the past hundred years have recently been contributed to *The Engineer* by its consultant editor, Dr. T. W. Chalmers. The first series was reprinted and published in book form in 1949 under the title of "Historic Researches: Chapters in the History of Physical and Chemical Discovery". The booklet under review is a similar reprint of the second series of articles and deals with Becquerel's discovery of the radioactivity of uranium; the work of the Curies and Rutherford; alpha-particles, beta- and gamma-rays and the radioactive disintegration series. The fourteen chapters in the volume correspond to the fourteen separate articles which appeared in *The Engineer*. The original double columns and type are retained.

The emphasis is on historical detail, but the subject-matter is treated from a modern point of view. In particular, where modern or more recent research during the past twenty years has produced additional or conflicting evidence, this is briefly mentioned. Artificial disintegration and nuclear research, the subjects of much interesting research and important discoveries during the past decade, are given only passing reference; but, doubtless, these will be dealt with in considerable detail in the third series of articles which, it is promised, will, after appearance in *The Engineer*, be reprinted in due course as a companion volume to the two already issued.

The booklet can be recommended to those who already possess a background of knowledge of atomic physics and wish to read a refreshing, not very mathematical, but technical and in some places somewhat difficult, account of the discovery of radio-activity and its subsequent development during the Rutherford era. S. WEINTROUB

Chemical Control of Insects

By Dr. T. F. West, Dr. J. Eliot Hardy and J. H. Ford. (Frontiers of Science Series.) Pp. xi+211. (London: Chapman and Hall, Ltd., 1951.) 15*s.* net.

A SMALL book such as this, which covers a wide field, must of necessity be lacking in detail; but it provides a useful survey, and a surprising number of the more important facts have been included. Most of the recent text-books on this subject have come from the United States, and there has been a tendency in them to omit references to the work done in other countries. This book may serve to rectify this tendency, since many references are given to British work, though the American and other work is not by any means neglected.

Some statements might be questioned, such as, "In general, however, cultural methods are, at the best, palliatives", and the word "paraffinity", meaning content of paraffin hydrocarbon, would appear to be of doubtful extraction. The advances in the field of insecticides are so rapid that some sections are already out of date; for example, hexaethyl tetraphosphate (HETP) is the only organo-phosphorus compound dealt with, and there is no mention of parathion or the phosphorus-containing systemic insecticides. The chapters on rotenone and pyrethrum are particularly good, and it is a pity, especially in view of Dr. West's own contributions to this subject, that the older versions of the formulæ for the pyrethrins and cinerins are first given and that the correction for the modern versions is in the form of an addendum.

Leaving aside these minor criticisms, the book should be very useful both to workers in the field of plant protection and others with a general interest in the subject. C. POTTER

Spotting British Birds

By S. Vere Benson. Pp. 231+33 plates. (London and New York: Frederick Warne and Co., Ltd., 1951.) 17*s.* 6*d.* net.

THIS book is for the amateur, and a beginner at that. It is a volume which will be very helpful to the novice not only with the identification of species but also by advice on what to look for, where to look for it and how to look for it. The remarks about methods of work are sound. The illustrations are from photographs by well-known bird photographers and line drawings by the author. The frontispiece is a colour-photograph of a red-throated diver on her nest and is in vivid hues. The little line-drawings are illustrations in the literal sense of the term and many of them are quite excellent. The subject is treated by district and locality, chapters being devoted to birds in the garden, birds of the woods, by rocky streams, birds of moor and mountain, etc. The book finishes with a classified list, a schedule of bird notes and songs and a comprehensive index. In the descriptions of individual birds will be found many personal observations and experiences which add much to the value of the whole. FRANCES PITT

SPEECH RE-INFORCEMENT IN ST. PAUL'S CATHEDRAL, LONDON

By P. H. PARKIN

Building Research Station, Garston, Watford

ST. PAUL'S CATHEDRAL is a very reverberant building; its reverberation time (at 500 c./s.) with a full congregation present is 6·5 sec. compared with 2·8 sec. in the Royal Albert Hall full or 1·7 sec. in the Royal Festival Hall full. These reverberant conditions—and several strong discrete echoes—interfere considerably with speech. Thus, even an experienced speaker can only make himself understood over, at the most, the dome area, and is completely unintelligible in the nave. Some form of speech re-inforcement is therefore necessary.

The re-inforced speech in any amplification system should be intelligible and natural. To be natural the speech must be of adequate loudness, undistorted, and should appear to come from the human speaker. Now to be intelligible, the sound reaching the listener direct from the loud-speaker or the human speaker must not be masked by the reverberant sound. Under steady-state conditions, it is simple to calculate the relative intensities of the direct and reverberant sound at a given distance, r, from the source[1], and the values of r at which these intensities become equal gives an indication of the relative merits of different sources for a given set of acoustic conditions.

With a point source of sound, r is equal to $\sqrt{(A/16\pi)}$, where A is the total absorption in the room. With a source of sound directed towards the congregation, $r = \sqrt{\{A.\alpha/16\pi\beta(1-\alpha.a_c)\}}$, where α is the fraction of the total energy, P, directed towards the congregation, β is the fraction of the solid angle into which the energy $\alpha.P$ is concentrated and a_c is the absorption coefficient of the congregation. If we assume values of 0·9 for α, 0·03 for β and 0·7 for a_c, the value of r for such a directional source is nine times the value of r for a point source. It should be noted that intelligibility is maintained up to greater distances than those given by the absolute values of r. This is mainly because of the ability of the ear to distinguish between wanted and unwanted sounds. Nevertheless, the relative values of r do indicate the advantage gained by the use of a directional source.

The most suitable type of directional loud-speaker for use in St. Paul's—and in most reverberant auditoria—is a line source[2] consisting of several individual cone loud-speakers mounted one above the other in a common baffle and all operating in phase. When the length of the line is large compared with the wave-length, this arrangement is highly directional in the vertical plane; the directional characteristic consists of a main lobe perpendicular to the line, with subsidiary lobes. The directional characteristics in three dimensions are surfaces of revolution about the line as an axis. The subsidiary lobes can be reduced to negligible intensities by tapering the line source, so that the strength varies linearly from its value at the centre to zero at either end.

A loud-speaker source based on this principle has been constructed to cover the dome area in St. Paul's. It is mounted close to the pulpit, with its bottom at ear height, and is inclined forward slightly so that the normal to its axis is towards the centre of the area. It was found that a line source of sufficient length (eleven feet) to be adequately directional at the lower frequencies was too directional at the higher frequencies. It is therefore arranged in two sections: the full length of the line is used for frequencies less than 1,000 c./s., and a secondary line source one-quarter the length is used for frequencies greater than 1,000 c./s. This source covers the dome area (about 110 ft. diameter) adequately; speech is intelligible even in the empty Cathedral (when a_c in the above equation is small), and in the full Cathedral it is not possible to hear any reverberant sound.

Speech re-inforcement in the nave area is by six similar but shorter line sources mounted on the pillars. The work of Haas[3] has shown how such subsidiary loud-speakers should be delayed in time in order to preserve the effect that all the sound is coming from the main source, in this case the pulpit. Haas used two loud-speakers separated spatially and both reproducing the same speech. The speech intensity from the first loud-speaker was kept constant while the speech from the second loud-speaker was delayed by various time intervals. Observers were asked to adjust the loudness of the second loud-speaker until it was equal in loudness to the first loud-speaker. It was found that the second loud-speaker, for delays of between 5 and 25 m.sec., had to be increased in intensity by 10 decibels relative to the first loud-speaker before it was equal in loudness. At lower relative intensities than this the second loud-speaker could not be identified as a separate source, independent of its position, and the apparent effect of the second loud-speaker was only to increase the loudness of the first loud-speaker.

This effect, conveniently known as the Haas effect, has been applied in St. Paul's. Thus the loud-speakers at the east end of the nave are delayed electrically by a time corresponding to the time taken for the sound from the pulpit loud-speaker to reach the nave, plus 5 m.sec. A listener at this position hears the sound from the pulpit first, followed 5 m.sec. later by the sound from the loud-speaker close to him. Although the intensity of the near loud-speaker sound is, say, 7 decibels greater than the pulpit sound, the listener is unaware of the near loud-speaker. The other loud-speakers down the nave are delayed in a similar manner by the appropriate times, and the illusion that all the sound is coming from the pulpit is maintained.

The electrical delays are introduced by using a rotating magnetic disk on which the sound is first recorded, then picked up by a series of heads spaced around the perimeter, and finally erased.

Three other points about this speech re-inforcement system, which has been recommended to the Dean and Chapter for use in the Cathedral, are worth mentioning. In reverberant auditoria, re-inforced speech is a little more natural if the frequency-range is restricted. A smaller frequency-range simplifies some of the other design problems, and in this case a range of 250–4,000 c./s. is used; frequencies outside this range are sharply attenuated. In the loud-speaker line source near the pulpit is a material

(cotton-waste) in which the velocity of sound is lower than that in air[4]. This delays the sound emitted from the back of the loud-speakers by a time equal to the time taken for the sound from the front to reach the back, and, as these two sounds are 180° out of phase, radiation to the back is considerably reduced. It is possible that the supersonic erasing head on the time-delay mechanism might fail, and the nave loud-speakers would then continue to repeat the last two or three words recorded on one revolution of the disk. To guard against this fault, a permanent-magnet erasing head is also used on the disk.

This work has been described in detail elsewhere[5]; it forms part of the programme of the Building Research Board of the Department of Scientific and Industrial Research, and this article is published by permission of the Director of Building Research. This experimental system was installed by Pamphonic Reproducers, Ltd., which also designed the time-delay mechanism.

[1] Meyer, E., Building Research Congress, Division 3, Part 1 (1951).
[2] Wolff, I., and Malter, L., *J. Acous. Soc. Amer.*, **2**, 2 (1930).
[3] Haas, H., *Acustica*, **1**, 2 (1951).
[4] Kalusche, H., *Z. angew. Phys.*, **2**, 10 (1950).
[5] Parkin, P. H., and Taylor, P. H., *Wireless World*, **58**, 2 and 3 (1952).

SPECTRA AND REACTION KINETICS OF RESPIRATORY PIGMENTS OF HOMOGENIZED AND INTACT CELLS

By Dr. BRITTON CHANCE

Johnson Research Foundation, University of Pennsylvania

THE pioneer studies of MacMunn[1], later followed by those of Keilin[2] and Warburg and his co-workers[3], have demonstrated the existence of absorption bands of oxidized and reduced forms of respiratory pigments of muscle tissues, yeasts, bacteria, etc., by means of visual spectroscopy. A quantitative study of only one component of the respiratory system has so far been obtained, and that is the carbon monoxide compound of *Atmungsferment*, measured by means of its photochemical action spectrum by Warburg and Negelein[4]. On the other hand, Keilin and Hartree's incisive chemical studies have revealed much information on the nature of cytochrome action and have indicated their sequential action from oxygen to succinate[5]; and Slater has added more detail to the cytochrome sequence and has clarified the reactions with reduced coenzyme-I[6].

As a consequence of the development of rapid and sensitive spectrophotometric techniques, it is now possible to record in a quantitative manner the changes in optical density that occur upon the reduction of the cytochrome and pyridine nucleotide enzymes of muscle homogenates or intact cells upon addition of their natural substrates[7]. The 'difference spectra' that are obtained in this manner are very useful for the identification of the various cytochrome components, for the comparison of the cytochromes of different cellular material, for the quantitative estimation of relative and absolute cytochrome content of various systems, and for studies of the dynamics of cytochrome action in various physical and chemical environments. The results of such studies lead to a quantitative evaluation of the properties of the succinic oxidase system and to a formulation of a physical chemical explanation of the action of insoluble enzymes of the respiratory pathway in either homogenates or intact cells.

This study does not represent the first attempt to measure photoelectrically the absorption bands of cytochrome. In 1934, Haas[8] measured the appearance of the ferrocytochrome-*c* band in yeast cells, as did Baumberger in 1938[9]; Arvanitaki and Chalazonitis measured spectra of nerve fibres[10]; and Lundegårdh has obtained curves for maize and wheat roots[11]. But little of this material is useful in an incisive study of the mechanism of cytochrome action.

Method. According to our studies, a respiratory enzyme is identified by the fact that its reduction coincides with the termination of the oxidase activity as the oxygen concentration falls to zero. As shown in Fig. 1, the linear decline of the concentration of dissolved oxygen caused by the oxidase reaction is followed continuously by a platinum microelectrode (Davies and Brink[11]), and the termination of the oxidase activity caused by the exhaustion of the oxygen supply is marked by the reduction of the cytochrome (in this case, component a_3 is measured at 445 mμ). This change in optical density is clearly synchronized with the oxidase activity. Such simultaneous recording techniques largely eliminate artefacts that might otherwise be mistaken for cytochrome reduction.

A very steady beam of intense monochromatic light illuminates an absorption cell (or a rapid-flow apparatus) containing the turbid cell suspension, which transmits less than 10 per cent of the incident light. Nevertheless, a photocurrent of 10^{-10}–10^{-11} amp. is obtained in an especially selected electron multiplier phototube when the spectral interval is 2 mμ or less at 550 mμ. This current is measured with an error limited only by shot noise, which corresponds to an error of optical density of 2×10^{-4}. The apparatus is arranged to record the changes in optical density at two wave-lengths of light simultaneously by means of two monochromators, a vibrating mirror, and related electronic circuits[7].

Difference spectra of the cytochromes of heart muscle preparations. (Most of the heart muscle preparations were carried out by Mrs. Helen Conrad and Mr. T. M. Devlin, to whom our thanks are due.) Upon addition of succinate to the oxidized cytochromes of a heart-muscle homogenate prepared according to the method of Keilin and Hartree[12], changes in optical density are measured at various wave-lengths upon reduction of the cytochromes, and the clear

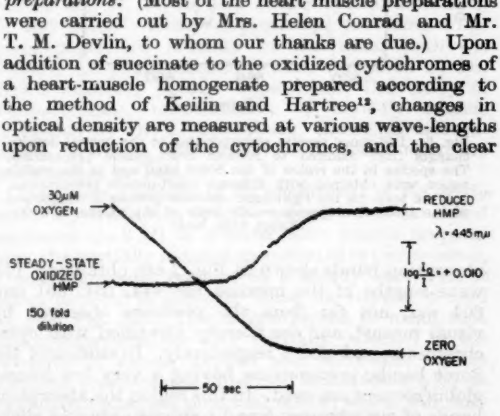

Fig. 1. Correlation between the termination of the oxidase activity and the reduction of cytochrome component-a_3 of the succinic oxidase system. The experiments were carried out in an open cuvette of the recording spectrophotometer with 150-fold dilution of the heart-muscle preparation. The oxidase activity is measured by means of a platinum micro-electrode inserted into the suspension. The time of addition of succinate is not shown and occurs some seconds before the record begins. (Expt. 58964)

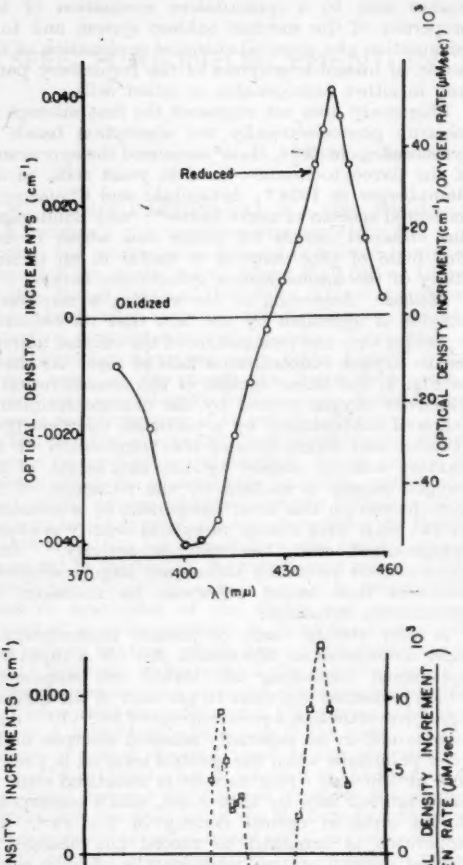

Fig. 2. Difference spectra corresponding to the optical density changes from oxidized to reduced heart-muscle preparation. The spectra in the region of the Soret band and in the visible region were obtained with different heart-muscle preparations, but the scale on the right-hand ordinate permits a comparison of the absorption spectra on the basis of the oxidase activity. (Expts. 643*c*, 701*b*)

absorption bands shown in Fig. 2 are obtained. The wave-lengths of the maxima are 444, 551, 561 and 604 mμ, not far from the positions observed by visual means[5], and are thereby identified with cytochromes-a_3, *c*, *b* and *a* respectively. In studies of the Soret bands, preparations having a very low hæmoglobin content are used. In this region the absorption bands of cytochromes-*b* and *c* appear only as a slight shoulder on the short-wave side of the band of cytochrome-a_3, but they are more distinct in yeast cells (see Fig. 5*a* later).

In accordance with the work of Keilin and Hartree[5] on the effect of cyanide and carbon monoxide upon cytochromes-*a* and a_3, we find that they may be independently measured at 604 and 444 mμ respectively, although there may be some contribution of cytochrome-*a* at 444 mμ. By measuring from the peak of the cytochrome-*c* band at 551 mμ to its isosbestic point at 541 mμ, the contribution of cytochrome-*c* to the spectrum is evaluated. The cytochrome-*b* band is similarly estimated from its peak at 561 mμ to the trough at 575 mμ. Thus much of the interaction of the absorption bands is avoided and quantitative estimates of the relative amounts of the cytochromes may be obtained: average values of the relative changes in optical density for six preparations are 6·2, 1·0, 1·0 and 0·7 for cytochromes-a_3, *a*, *c* and *b* respectively.

Effects of light scattering. Light scattering by the turbid material could cause errors in the changes in measured optical density, and therefore the absorption of cytochrome-*c* has been remeasured in the presence of two substances that diminish the light scattering[5]. First, the addition of 67 per cent glucose greatly increases the refractive index of the medium surrounding the particles, but does not measurably decrease the change in optical density at 551 mμ. Secondly, a decrease of only 25 per cent in the change in optical density at 551 mμ occurs upon addition of 2 per cent cholate, which allows the cytochrome-*c* to leave the particles. No large error can be attributed to light scattering under the conditions of our experiments, and we shall proceed to estimate the cytochrome content with no correction for light scattering.

Cytochrome content of the succinic oxidase system. The concentrations of a solution of these cytochromes spectrophotometrically equivalent to the insoluble material is termed the 'cytochrome content' and is calculated from the estimated changes of molecular extinction coefficients ($\Delta\varepsilon$) as follows. In the case of cytochrome-*c*, the content is computed directly from known data on the soluble material,

$$[c] = \frac{\Delta D_{551} - \Delta D_{541}}{19{\cdot}1} \text{ m}M \text{ [13]}.$$

For cytochrome-*b*, two values of the value of $\Delta\varepsilon$ are available, one for cytochrome-b_2 [14] and one for cytochrome-*b* from diphtheria bacteria[15]. Both these data give results very close to 20 cm.$^{-1}$ × mM^{-1}, and

$$[b] = \frac{\Delta D_{561} - \Delta D_{575}}{20} \text{ m}M.$$

In the case of *Atmungsferment* of yeast cells the photochemical absorption spectrum of the carbon monoxide compound[4] gives a value of $\varepsilon_{421} = 161$ cm.$^{-1}$ × mM^{-1}. We have observed the absorption peak of ferrocytochrome-a_3 to shift from 444 to 430 mμ in respiring yeast cells in the presence of carbon monoxide, and Keilin and Hartree previously found the same shift in heart muscle[5] which we have verified by our spectrophotometric method. None of these data agrees with the result of Ball *et al.*, who find the a_3-CO band at 423 mμ in a desoxycholate-treated preparation that was probably contaminated with hæmoglobin[16]. Thus it appears justifiable to identify Warburg's data on *Atmungsferment* with our data on heart muscle. By a comparison of the Soret spectra of the oxidized and reduced forms of the pure dichroic-hæmin enzyme, lactoperoxidase[17], and its carbon monoxide compound with the corresponding

spectrum of cytochrome-a_3, proportionality constants are derived, and a value of $\Delta\varepsilon_{444} = 180$ cm.$^{-1}$ × mM^{-1} is computed for cytochrome-a_3:

$$[a_3] = \frac{\Delta D_{444}}{180} \text{ m}M.$$

(According to Lemberg[18], the analogy between the hæmins of these verdoperoxidases and that of the respiratory enzyme is not as close as might be desired, but the chemical and spectroscopic properties of the intact enzymes are rather similar.) In the case of cytochrome-a, no carbon monoxide compound is known at *p*H 7, and this is a point in common with verdoperoxidase[19], which is a non-autoxidizable green hæmin enzyme with a single band in the red (at 630 mμ) in the difference spectrum of the oxidized and reduced forms. We thus assume that the values of $\Delta\varepsilon_{630}$ for verdoperoxidase (14 cm.$^{-1}$ × mM^{-1}) is identical with the value for cytochrome-a at 605 mμ. Thus

$$[a] = \frac{\Delta D_{605}}{14} \text{ m}M.$$

On the basis of these data, the relative content of these four cytochrome components in an average preparation is 1, 2, 1·6, 1·0 for cytochromes-a_3, a, c and b respectively; and on the basis of a titration of heart muscle preparation with antimycin-a[20], we find the relative content of Slater's factor to be 1·2 (assuming antimycin binds two iron equivalents). Thus there is remarkable similarity in the content of five components of the succinic oxidase system, sufficient similarity to allow the suggestion that the 'succinic oxidase assembly' consists of roughly one each of the components. A more exact stoichiometry has not yet been proved.

Studies of the cytochrome content of the giant mitochondria of the flight muscle of the blow-fly[21] give a rather similar content for cytochromes-a and a_3, the relative values being 1, 1·6, 3·7, 3·5 respectively for cytochromes-a_3, a, c and b. The content of cytochromes-c and b exceeds that of the heart muscle homogenates.

Turnover numbers of the cytochrome components. On the basis of the relative concentrations of the cytochrome components, their turnover number in succinic oxidase activity at 26° is readily calculated as the quotient

$$\frac{\mu M \text{ O}_2/\text{sec.}}{\Delta D_{444}} = K_4,$$

and has values ranging over 80 for a very active preparation. By converting from oxygen to iron equivalents (4 ×) and from ΔD_{444} to concentration in μM $\left(\times \frac{10^3}{180}\right)$,

Table 1. Comparison of the Calculated Values of Turnover Numbers for the Cytochrome Components of Various Succinic Oxidase Preparations and Respiring Cells at 26° (all values sec.$^{-1}$)

Source	$K_4 = \frac{\mu M \text{ O}_2/\text{sec.}}{\Delta D_{444}}$	Turnover numbers				
		a_3	a	c	b	'factor'
Heart muscle (horse or pig)	80 (max.)	58	29	36	58	48
Pea seedlings	35	25	—	—	—	—
Flight muscle (mitochondria)	25	18	11	5	5	—
Yeast cells (baker's)	220	160	58	18	46	—

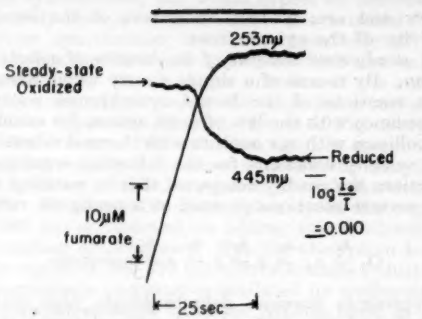

Fig. 3A. Correlation between the rate of production of fumarate and the extent of reduction of cytochrome-a_3, as measured by the double-beam spectrophotometer. 50-fold dilution of heart-muscle preparation

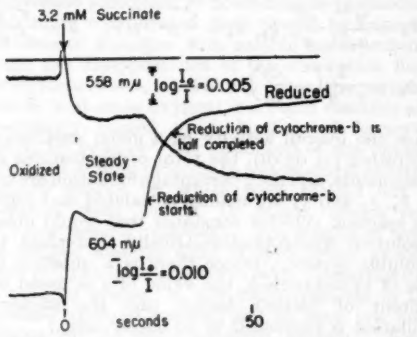

Fig. 3B. Correlation between the kinetics of reduction of cytochrome-a and cytochrome-b. The moment at which succinate is added to the oxidized heart-muscle preparation is indicated and is followed by the steady-state operation of these enzymes. Reduction occurs when the dissolved oxygen is exhausted. An inward deflexion of these traces corresponds to an increase of optical density. (Expt. 763)

the turnover number of cytochrome-a_3 is $0{\cdot}72K_4$, or 58 sec.$^{-1}$ for the highly active preparation. The other values are 29, 36, 58 and 48 for cytochromes-a, c, b, and Slater's factor respectively, providing these components are actually in the main pathway. Results for plant succinic oxidase (prepared by Dr. Helen Stafford, Botany Department, University of Pennsylvania), mitochondria of blow-fly muscle (prepared by Dr. L. Levenbook, Biological Laboratories, Harvard University) and yeast cells are summarized in Table 1.

Percentage oxidation of the cytochromes in the steady state. Upon addition of a few microlitres of saturated succinate ($\sim 2\,M$) to aerated heart muscle preparation, the partially reduced spectrum of cytochromes-a, b and c appears, remains in a steady state and is about doubled in intensity when the oxygen is used up (see Fig. 3*B*). This is interpreted to mean that the cytochromes are only partially oxidized in the presence of excess oxygen and succinate. (This dynamic phenomenon must not be confused with an oxidation-reduction potential effect[9], which will only set the limits of reduction following the steady state.) By measuring at the appropriate wave-lengths, described above, the percentages of steady-state oxidation for six preparations are 87, 69, 64, 68 for cytochromes-a_3, a, c and b. These percentages are sensitive to inhibitors and other factors as described

below and are, in fact, indicators of the level of activity of the cytochromes.

A steady-state analysis of the kinetics of cytochrome action. By means of a simple theory which assumes that reactions of the bound cytochromes occur in accordance with the law of mass action, for example, by collision with one another with thermal vibrations, the velocity constants for the following sequence of reactions are readily computed if it is assumed that the reverse reactions proceed at a negligible rate :

$$O_2 \xrightarrow{k_1} a_3 \xrightarrow{k_2} a \xrightarrow{k_3} c \xrightarrow{k_7} s \xrightarrow{k_9} \text{succinate.} \qquad (1)$$

s represents succinic dehydrogenase plus Slater's factor, and the oxidized and reduced forms of the enzymes are appropriately identified (for example, a_3'', a_3'''). The oxygen and succinate concentrations at any time are x and y respectively.

$$k_2 = \frac{a'''}{a_3'''} \cdot \frac{c''}{a''} k_3, \quad k_3 = \frac{c'''}{a'''} \cdot \frac{a''}{c''} k_7, \quad k_7 = \frac{s'''y}{c'''s''} k_9,$$

$$k_9 = \frac{1}{s'''y}\left(-\frac{dy}{dt}\right).$$

Since the overall activity at a given succinate concentration ($-dy/dt$), the total concentrations of the components, and their percentage oxidation are known, k_2, k_3, k_7 and k_9 are readily calculated and represent the reaction velocity constants that would obtain in a solution spectrophotometrically equivalent to the insoluble system. (Since there is a question of the role of cytochrome-b, the value of s is based on the content of Slater's factor, and the steady-state oxidation is estimated to be 50 per cent.)

In the case of the reaction with oxygen, cytochrome-a_3 is not largely oxidized in the steady-state that non-steady-state conditions must be used. The velocity constant is calculated from oxidase activity data at low oxygen concentrations as in Fig. 1 from the equation

$$k_1 = \frac{1}{xa_3''}\left(-\frac{dx}{dt}\right),$$

which applies to any portion of the traces of Fig. 1. The experimental results and the tentative values of the reaction velocity constants for the equivalent system are summarized :

Reaction velocity constant $\times 10^{-6}$ ($M^{-1} \times$ sec.$^{-1}$)	10	30	30	40	0·01
	$O_2 \rightarrow a_3$	$\rightarrow a$	$\rightarrow c$	$\rightarrow s$	$\rightarrow$ succinate (2)
Relative content	1·0	2·0	1·6	1·2	
Per cent oxidation	87	69	64	(50)	

The magnitudes of these velocity constants are quite reasonable in view of the measured rates of reactions of peroxidases, catalases[22], and myoglobin[23].

The extent to which the data on the spectrophotometrically equivalent soluble system apply to the actual insoluble system has been considered in detail. The velocity constants for the external reactions (those with oxygen and succinate) are probably about the same for the insoluble system, because the diffusibility of the soluble enzyme molecule is already almost negligible compared to that of the substrate molecule. If the internal enzymes react with each other by collision and are physically bound to the heart muscle particles, their spacing would be of the order of a molecular diameter, and consequently their effective concentration would be very large. On the other hand, a sequential arrangement of these bound cytochromes in 'succinic oxidase assemblies' containing roughly one each of the components may occur, and interaction between the corresponding members of different assemblies may not be possible. This consideration would reduce the effective concentration of closely packed cytochromes, since an internal enzyme would react only with its neighbours in the sequence. The best estimate of the effective concentration of the internal enzymes is based on kinetic data : soluble cytochrome-c and 'solubilized cytochrome oxidase'[24] react in solution with very nearly the same velocity constant as that computed above for the equivalent soluble system of heart muscle preparation ($\sim 10^7\ M^{-1} \times$ sec.$^{-1}$). Thus the effective concentration of the internal enzymes may be of the same order as that of the spectrophotometrically equivalent system. The values of relative content given above may then be regarded as preliminary estimates of the micromolar concentrations of the internal enzymes.

Kinetic studies of the reduction of the cytochromes. The kinetics of reduction of the cytochromes have been examined with respect to one another and with respect to the termination of the overall enzymatic activity as the oxygen concentration falls to zero as shown in Figs. 3*A* and *B* respectively. These records were obtained with a double-beam spectrophotometer which permits simultaneous recording at two wave-lengths in the visible and ultra-violet[7]. Fig. 3*A* shows that the reduction of cytochrome-a_3 and the decrease of fumarate production occur at the same time (the equivalent oxygen affinity corresponds to $2 \times 10^{-6}\ M$ from this record). Similar simultaneous studies of cytochromes-a_3, a and c show that their reduction also occurs at very nearly the same time, even when studied at 4°. In detail, the initiation of the reduction of cytochrome-c lags behind that of cytochromes-a and a_3, but then runs faster and is about 10 per cent ahead at the half-way point. The reduction of cytochrome-b lags considerably, as is shown by Fig. 3*B* ; its reduction does not start until that of cytochrome-a has proceeded appreciably, and is only half completed when that of cytochrome-a has reached 80 per cent. Thus the reduction of cytochrome-b is prolonged not only after that of the other cytochromes but also continues after the production of fumarate has ceased. An electric analogue computer study of the reaction mechanism of equation 2 shows that this behaviour is inconsistent ; cytochrome-b does not participate in the pathway of electron transfer provided by this simple mechanism. (A general theorem applicable to enzyme systems of this type is that the time derivatives of the concentrations of the intermediate compounds must be zero when the time derivatives of the substrate concentrations are zero.)

No evidence of time separation in the oxidation of the cytochromes has yet been obtained (4°, $\sim 1 \times 10^{-6}\ M$ oxygen, time resolution $\sim 0{\cdot}5$ sec.).

Kinetics of reduction of cytochromes-a, b and c in cyanide-inhibited systems. In a cyanide-inhibited system, it is possible to measure the speed with which the various cytochromes are reduced by succinate and to compare these rates with the values of oxidase activity that are obtained in the uninhibited system. This procedure was used in 1934 by Haas, who studied the cytochrome-c band of yeast cells[8]. Again, these studies are most effectively carried out at low temperatures (4°), and the data of Table 2 have been so obtained. The uninhibited oxidase activity is cal-

Table 2. COMPARISON OF THE RATES OF SUCCINATE REDUCTION OF CYTOCHROMES-*a*, *b* AND *c*, WITH THE ESTIMATED VALUES OF TURNOVER OF THESE COMPONENTS REQUIRED BY THE MEASURED OXIDASE ACTIVITY. (4° C.) (EXPTS. 774 AND 775.)

Estimated concentration of cytochromes-*a*, *c* and *b*, 4, 2·7 and 1·7 μM respectively

Succinate (μM)	32	320	800	3,200
Oxidase activity (μM O_2/sec.)	0·06	0·12	0·19	0·26
Estimated turnover numbers (sec.$^{-1}$)				
for cytochrome-*a*	0·06	0·12	0·19	0·26
for cytochrome-*c*	0·09	0·18	0·28	0·38
for cytochrome-*b*	0·14	0·28	0·44	0·61
Measured rates of reduction in cyanide-inhibited heart-muscle preparation (sec.$^{-1}$)				
for cytochrome-*a*	0·034	0·090	0·18	0·39
for cytochrome-*c*	—	0·17	0·28	0·28
for cytochrome-*b*	—	0·004	0·0140	0·009

culated from the time interval between the addition of substrate and the exhaustion of dissolved oxygen, and the rates are computed for various initial succinate concentrations. These values are converted into turnover numbers by means of the estimated cytochrome concentrations, and may be compared with the velocity constants for the reduction of the cyanide-inhibited material. It can be seen that there is reasonable agreement for cytochromes-*a* and *c*, and therefore the rate of reduction of these cytochromes is sufficiently rapid to explain the measured oxidase activity (not only at 4° but also at 26°). But the rate of reduction of cytochrome-*b* by succinate is so slow that only 2 per cent of the oxidase activity could be carried through this cytochrome component. Our cyanide concentrations and reaction times are much too small to cause the inhibition of succinic dehydrogenase observed by Tsou[25]. It is proposed that cytochrome-*b* is linked to succinic dehydrogenase as follows:

$$O_2 \rightharpoonup a_3 \rightharpoonup a \rightharpoonup c \rightharpoonup s \rightharpoonup \text{succinate.} \qquad (3)$$

fast oxidation | slow reduction

b

Effect of physical and chemical factors upon the steady state of cytochrome action. The steady-state oxidation of the cytochromes may be varied over wide ranges by selective inhibitors in a manner that indicates the point of action of the inhibitor. This is clearly illustrated by the effect of antimycin-*a* (Ahmad, Schneider and Strong[26]) upon the cytochrome components as shown in Fig. 4. According to equation 2, representing the mechanism of action

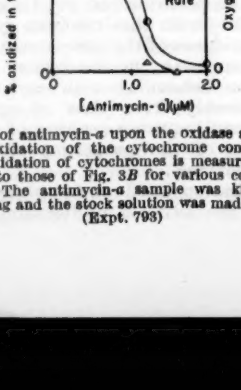

Fig. 4. Effect of antimycin-*a* upon the oxidase activity and the steady-state oxidation of the cytochrome components. The steady-state oxidation of cytochromes is measured as in experiments similar to those of Fig. 3*B* for various concentrations of antimycin-*a*. The antimycin-*a* sample was kindly given by Dr. F. M. Strong and the stock solution was made up in ethanol. (Expt. 793)

of the cytochromes, one would expect an increase in the steady-state concentrations of the oxidized form of those cytochromes on the oxygen side of the inhibited component and a decrease for those on the succinate side. Also a larger inflexion of the curves for the components nearer the inhibited component would be expected. Thus the traces of Fig. 4 represent the effect of the inhibitor upon a component acting between cytochrome-*c* and succinic dehydrogenase, Slater's factor, in agreement with Potter and Rief[20]. No change in optical density in the region 530–565 mμ is observed on adding this inhibitor to the oxidized cytochromes. But the absorption band in the region of 555–570 mμ upon succinate reduction of heart-muscle preparation inhibited by antimycin-*a* is somewhat stronger than the 561-mμ band in the uninhibited enzyme. This modification of the absorption band may be caused specifically by Slater's factor or by a compound of cytochrome-*b* and the inhibitor.

The cyanide inhibition of heart-muscle preparation is much more complicated than would be expected on the basis of analogies with soluble hæmoproteins. Although the disappearance of the absorption band of ferrocytochrome-a_3 at 444 mμ upon the addition of cyanide (and some oxygen) is a rapid reaction and is presumably caused by a binding of ferricytochrome-a_3 by cyanide[5], the inhibition of the oxidase activity upon adding cyanide to the oxidized enzyme, preliminary studies on which were carried out in collaboration with Dr. E. C. Slater, occurs very slowly (over several minutes). The results of these studies suggest that the form of cytochrome oxidase inhibited by cyanide is present in large concentrations in the reduced system, in low concentrations in the steady-state oxidized system, and in very low concentrations in the fully oxidized system. Some reconsideration of the mechanism of cyanide inhibition of the succinic oxidase system is required, but a full explanation is difficult in the absence of any evidence for competition between oxygen and cyanide.

Whereas the effect of temperature upon the succinic oxidase activity is very large ($\mu \sim 11{,}000$ cal.), the steady-state oxidation of the cytochromes varies but little over the temperature range 4°–40° and corresponds to less than 1,000 cal. On the basis of the mechanism of equation 2, the velocity constants for the reactions of the cytochromes with one another have about the same temperature dependence as those that react with oxygen and succinate.

Studies of the respiratory enzymes of intact yeast cells. The methods that have been used for heart-muscle particles are also suitable for studies of five of the respiratory enzymes of baker's yeast cells, cytochromes-a_3, *a*, *c*, *b*, and the pyridine nucleotide enzymes. The difference spectra of the components have been obtained as shown in Fig. 5*a* and correspond to a sequence of optical densities of 4·5, 1, 4·2, 1·8 and 29, giving a relative content of 1, 2, 8·9, 3·6 and 200 respectively. (Euler *et al.*[27] found 250 μgm. of coenzyme-I in 1 gm. of yeast. Our data give 300 μgm. of total pyridine nucleotides per gram of our yeast.) The value of turnover numbers of the cytochrome components is 160, 58, 18 and 46 at 26°, assuming that they are in the main pathway of electron transfer. The pyridine nucleotide content of the yeast cells is relatively enormous compared with that of the cytochromes; and the content of cytochromes-*c* and *b* is larger than in the heart-muscle preparations.

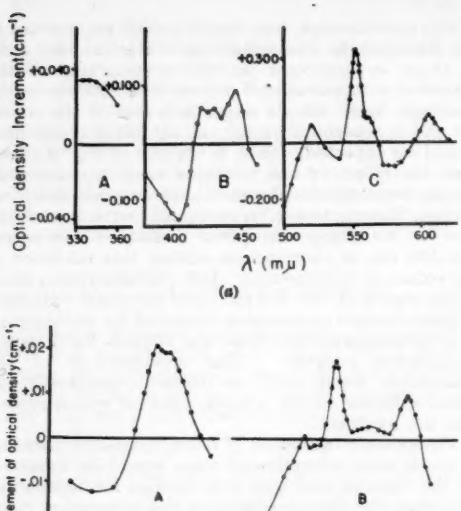

Fig. 5. Difference spectra of the cytochrome components of a yeast and a bacterial culture

Fig. 5a shows the changes in optical density from the steady-state to reduced for baker's yeast in the ultra-violet, violet, and visible regions of the spectrum. The dilutions of the yeast cells were 22·5, 4·5 and 1 for *A*, *B* and *C* respectively, and the changes in optical density are computed per cm. The value of the oxygen rate for the 4·5-fold dilution was 100 μM O_2/sec. at 25°, corresponding to $K_s = \mu M\ O_2/\text{sec.}/\Delta D_{444} = 110$. (Expt. 719a, *b* and 791)

Fig. 5b shows the difference spectrum of *Aerobacter aerogenes* reduced in the presence of 3·3 mM glucose. In *A*, the dilution of the cells is 6-fold, and in *B*, 1·5-fold. $K_s = \frac{\mu M\ O_2/\text{sec.}}{\Delta D 433} = 150$ at 25°

The reduced pyridine nucleotides (DPNH) are not stable under anaerobic conditions; at the end of a minute their concentration has fallen to half the maximum value, presumably because of the delayed initiation of anaerobic glycolytic reactions. The (DPNH) band is shifted towards 325 mμ, presumably by binding to protein in the manner of alcohol dehydrogenase[28]. Such bound reduced pyridine nucleotide is more closely associated with the cytochromes than the free reduced pyridine nucleotides.

The yeast cells also contain a peroxidase[29] which, in common with other peroxidases[30], rapidly oxidizes ferrocytochrome-*c* in the presence of peroxide. By adding methyl hydrogen peroxide (that is, not decomposed into oxygen by catalase[31]) to the reduced cytochromes of yeast cells, oxidation of not only cytochrome-*c* but also the pyridine nucleotide enzymes is obtained to the extent of 75 and 65 per cent respectively. This is the first direct evidence for the intracellular oxidation of respiratory enzymes via the peroxidase – peroxide system, but the function of this system with endogenous peroxide is not proved.

In the presence of peroxide, cytochrome-a_3 is bound in what appears to be a peroxide complex and remains so bound until the peroxide is used up; only then may the oxidized form of cytochrome-a_3 be obtained.

Difference spectra of some bacterial cytochromes (Dr. Lucile Smith has collaborated in these studies). The visible and ultra-violet absorption spectra of a few bacterial strains have been measured and the result for *Aerobacter aerogenes* (a culture kindly given by Dr. A. Tissières, Molteno Institute, University of Cambridge) is shown in Fig. 5*b*. The peak of the cytochrome-a_3 lies at 628 mμ and cytochrome-b_1 at 561 mμ. A small peak is also found at about 590 mμ in accordance with Tissières[32]. In the region of the Soret band there is a single peak at 430 mμ, presumably the γ-band of cytochrome-b_1. The shoulder in this Soret band is unidentified, since it is well removed from 444 mμ, where the γ-band of cytochrome-a_3 would have been expected in view of the photochemical data of Kubowitz and Haas on *Acetobacter*[33], and in view of the high respiration of these cells ($\mu M\ O_2/\text{sec.}/\Delta D_{430} = 150$ at 25°). But carbon monoxide does not reveal the characteristic cytochrome a_3-CO absorption bands, and those attributable to a_3-CO differ markedly from those of hæmoproteins: the Soret band (437 mμ) is less than one-third as large as the visible band (645 mμ). The earlier view that cytochrome-a_3 is a bile pigment hæmochromogen[17] is supported.

Summary. Effective spectrophotometric methods for the study of spectra and kinetics of the respiratory pigments of muscle homogenates or intact cells have been developed. At present, an intensive and detailed study of the four cytochrome components of heart-muscle homogenates has clearly defined the spectra representing the difference between their oxidized and reduced states, has led to estimates of the relative and absolute amounts of these cytochromes, and has permitted an estimate of the velocity constants with which such insoluble cytochromes may react with each other and with their substrates. The latter calculations are made on the basis of a simple hypothesis that requires only that the bound cytochromes collide with each other by thermal vibrations about the point of their attachment to the particle. The kinetics of reduction of these cytochromes by succinate in uninhibited and in cyanide-inhibited systems has been measured. In the uninhibited systems, the reduction of cytochrome-*b* lags considerably behind the nearly simultaneous reduction of cytochromes-a_3, *a* and *c* and the cessation of the overall activity. In the inhibited system, the velocity constant for the reduction of cytochrome-*b* is so small that only 2–10 per cent of the measured oxidase activity (in the uninhibited system) could be accounted for. Thus cytochrome-*b* is regarded more as an indicator of succinic dehydrogenase activity than as a component in the main pathway of electron transfer of heart muscle preparations.

In respiring yeast cells, the kinetics and spectra of not only the four cytochrome components, but also the pyridine nucleotide enzymes may be studied in detail. In the anaerobic yeast, direct evidence for the intracellular oxidation of respiratory enzymes via the peroxidase – peroxide system has been obtained, but no proof of the functions of this system with endogenous peroxide can yet be given.

In a bacterial strain that contains cytochrome-a_3, there was no evidence of the characteristic absorption band of cytochrome-a_3 in the region of the Soret band, and the behaviour with carbon monoxide differs considerably from that of cytochrome-a_3. This finding may require a revision of our views on the uniformity of the properties of the 'oxygen transporting enzyme'.

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OBITUARIES

Sir Peter Henry Buck, K.C.M.G. (Te Rangi Hiroa)

THE death of Sir Peter Henry Buck (Te Rangi Hiroa) on December 1 brought an end to one of the most extraordinary and distinguished careers the world has known. His passing is a bitter loss; but he has left to us a priceless heritage. The influence of his warm and charming personality will endure so long as there are people who had the privilege of knowing him. The results of his lifelong efforts to describe accurately the arts and crafts of the peoples of Polynesia will remain as landmarks of scientific study in the field of anthropology. His contributions to our understanding of people and their problems are being incorporated as a part of an enduring body of knowledge about mankind.

Sir Peter was born in New Zealand on August 15, 1880. His father, William Henry Buck, was an Irishman; his mother, Ngarongo-ki-tua, was a native Maori of high status. After spending most of his younger years among his mother's people, he married Margaret Wilson, of Gremouth, New Zealand, in 1905 and entered the University of New Zealand. Receiving his M.D. in 1910, he served as a member of the New Zealand Parliament until 1914. From then until 1919 Dr. Buck served with the first Maori contingent of the New Zealand Medical Corps in Egypt and Gallipoli, achieving the rank of major. During this period his wife was a hospital nurse in London and in Alexandria. They were decorated for their war services, Mrs. Buck with the M.B.E., and Dr. Buck with the D.S.O.

After the War, Dr. Buck became director of Maori hygiene in New Zealand, leaving in 1927 to serve as ethnologist for the Bishop Museum in Honolulu. In this latter capacity (accompanied by his wife) he made numerous field trips to the islands of Polynesia to collect detailed information on native customs, which served as the basis for his many publications on Polynesian ethnology. Since they were able to speak the native language of the people they visited and enjoyed intimate knowledge of one Polynesian society, the Maori, they accomplished far more in their research than would otherwise have been possible. In 1936 Dr. Buck was made director of the Bishop Museum and professor of anthropology at Yale University. In 1946, he was made a knight commander of the order of St. Michael and St. George in recognition of his scientific research.

CLELLAN S. FORD

Dr. Arthur Bulleid

DR. ARTHUR BULLEID, who died at his home, Dymboro, Midsomer Norton, Somerset, on December 27, at the age of eighty-nine, will be best remembered as the discoverer of the Iron Age '*B*' site known as the Glastonbury Lake Village.

Bulleid, who was by profession a medical practitioner, had an early opportunity of cultivating a taste for archæology, and having read Keller's book on the Swiss Lake-dwellings, Munro's "Lake Dwellings of Europe" and other works, he became imbued with the idea that remains of a somewhat similar nature were to be found in the swamps of central Somerset. So, in his rambles over the moors, he was on the look-out for possible sites, and he visited peat-cutting operations in the vicinity. A little later, he found the mounds about a mile north of Glastonbury, on the road to Godney, which raised a suspicion in his mind that they were artificial. Certain remains which turned up on mole-heaps settled the point, and Arthur Bulleid got into touch with Dr. Robert Munro and Sir W. Boyd Dawkins and other archæologists. This resulted in the British Association forming a Lake Village Committee in 1893, and making monetary grants from year to year towards the work. The excavations, however, began in 1892 under the direction of Dr. Bulleid: they were found to be unique and became widely known.

In the same year, due to Bulleid's inquiries and his keenness, a flat-bottomed dug-out boat, 17 ft. in length, was recovered at some little distance from the lake village, and is now preserved in the Glastonbury Museum.

The first series of excavations extended until 1898; then there was an interval of six years, except for a comparatively small exploration conducted in 1902 by Mr. H. St. George Gray. Further operations were resumed in 1904 under the joint direction of Dr. Bulleid and Mr. Gray. This work was completed in 1907. In 1911, Vol. 1 of a large fully illustrated report in royal quarto size was published, followed in 1916 by Vol. 2. Before the issue of Vol. 1, Messrs. Bulleid and Gray began a long series of excavations in 1908 on the site of the neighbouring lake village at Meare, which is in two separate areas known as

the West and East villages. Vol. 1, on the West village, was issued in 1948, and Vol. 2 is now in preparation, and will include Dr. Bulleid's description of the dwellings and further chapters by Mr. St. George Gray on the finds, which are very numerous. The Meare exploration has continued season by season up to date except during the period of the two World Wars.

Dr. Bulleid's archæological interests extended beyond the lake villages, and he was a most careful, accurate and painstaking observer, and exceedingly pleasant to work with; he would go to any trouble to achieve satisfactory results. Moreover, he was a good draughtsman—so essential an attainment for archæological work and especially in connexion with illustrating published reports. Bulleid was never happier than when working at the lake villages, where he made many friends who appreciated his archæological enthusiasm.

For the *Proceedings of the Somerset Archæological Society* he wrote valued papers, notably "The Chambered Barrows of North Somerset", "The Ancient Trackway in Meare Heath" and "The Shapwick Boat", and in collaboration with Dr. Wilfrid Jackson "The Burtle Sand Beds in Somerset" (in two papers).

Bulleid was one of the very few remaining members of the Somerset Archæological Society who joined in the last century, namely, in 1893; and he was elected a vice-president in 1924. He became a Fellow of the Society of Antiquaries of London in 1896, of which body he was for some years one of the local secretaries for Somerset. He is survived by his wife and all his children—two sons and four daughters.

NEWS and VIEWS

Physiology at Cambridge: Prof. B. H. C. Matthews, C.B.E., F.R.S.

Prof. E. D. Adrian, Nobel prizeman in medicine in 1932, and president since 1950 of the Royal Society (see *Nature*, **166**, 978; 1950), has recently been elected master of Trinity College, Cambridge. He has now retired from the chair of physiology in the University which he has held with great distinction since 1937, and he has been succeeded by Dr. B. H. C. Matthews, reader in experimental physiology in the University. Prof. Matthews is one of the foremost authorities on the activity of sense organs and nervous structures as well as a pioneer in the modern developments of electro-physiological technique. With the advent of the valve amplifier after the First World War, it became possible to record the very small potential changes due to individual nerve fibres, but convenient recording instruments were not then available. Prof. Matthews not only designed the robust moving-iron oscillograph which met the need, but also has been responsible for much of the subsequent improvement in the design of amplifiers for biological work. He showed his great technical skill in the classical investigation of sensory discharges from muscles which he published in 1933 and in his later work on conduction in the spinal cord. In 1939, his familiarity with a wide range of experiment made him an ideal head of the Physiological Laboratory which was set up at Farnborough to study problems of aviation medicine. He was made a reader on his return to Cambridge in 1946, but still acts as an adviser in aero-medical research. Electro-physiologists in many countries owe their initial training to him and will join in congratulating him on his election to the professorship.

It is with deep regret that we announce the death of His Majesty The King

Institute of Metals: Awards

The Council of the Institute of Metals has made the following awards of medals for 1952:

Institute of Metals (*Platinum*) *Medal:* Mr. W. S. Robinson, until recently president of the Consolidated Zinc Corporation, Ltd., in recognition of his outstanding services to the non-ferrous metal industries in developing the Australian zinc–lead industry and the British zinc industry.

Rosenhain Medal: Prof. André Guinier, Conservatoire National des Arts et Métiers, Paris, in recognition of his outstanding contributions in the field of physical metallurgy, particularly in connexion with precipitation phenomena.

W. H. A. Robertson Medal: Mr. C. E. Davies, for his paper on "The Cold-Rolling of Non-Ferrous Metals in Sheet and Strip Form" (*J. Inst. Metals*, **78**, 501 (1951)).

Textile Institute: Awards

The Textile Institute has made the following awards: *Institute Medal*, awarded in recognition of distinguished services to the textile industry in general, and to the Institute in particular, to Prof. W. E. Morton, professor of textile technology, Manchester College of Technology, and to Mr. W. R. Wadsworth, managing director, Wm. Frost and Sons, Ltd., Macclesfield; *Service Medal*, awarded in recognition of valuable services to the Institute, to Mr. F. Kendall, textile consultant and manager of the Physical Testing Laboratory, Bradford Dyers' Association, and to Mr. R. J. Smith, textile technologist at Imperial Chemical Industries, Ltd., Dyestuffs Division, Blackley, Manchester.

British Commonwealth Scientific Conference

A British Commonwealth Scientific Conference will be held in Australia during February 18–March 9 under the chairmanship of Dr. Clunies Ross, chairman of the Australian Commonwealth Scientific and Industrial Research Organization. The Conference will commence at Canberra and after a few days will then adjourn to Melbourne. The delegates for

the United Kingdom are Sir Ben Lockspeiser, secretary of the Department of Scientific and Industrial Research, Sir William Slater, secretary of the Agricultural Research Council, Dr. F. H. K. Green, representing the Medical Research Council, and Dr. Alexander King, head of the Intelligence Division of the Department of Scientific and Industrial Research. All the self-governing countries of the Commonwealth will send delegations, and Colonial research will be represented by Dr. G. A. C. Herklots, of the Colonial Office. The United States Government is also sending observers. The main object of the Conference is to improve collaboration in research throughout the British Commonwealth, in particular the spreading of information and personal contacts between scientific workers. In addition, consideration will be paid to the furthering of relations with international research organizations, both those within the United Nations Organization and others. The detailed programme for the Conference is as follows. Under the heading of industrial subjects will be discussed industrial microbiology, the utilization of seaweed, research on metal casting, sulphur production, the utilization and beneficiation of low-grade ores and wastes, research on wool fibre, soil mechanics, and the utilization of solar energy by physical or biological means. Agricultural topics include animal climatology, the assessment of new insecticides and fungicides, grassland research in tropical and sub-tropical climates, and the sterility and infertility of animals. Among the medical subjects are climatic physiology, with special reference to living conditions in the tropics, the effect of radioactive tracers on living cells in plant and animal research, medical biochemistry, with particular reference to such problems as the standardization of methods of examining blood constituents, the geographical incidence of dental caries, and the geographical distribution of differences in the physical standards between different countries and between different types in a single country.

New Chair of Geology at the Rice Institute, Houston, Texas

A NEW chair, to be known as the Harry Carothers Wiess chair of geology, has recently been established in the Rice Institute, Houston, Texas, by a gift of 1,570,000 dollars from Mrs. Olga Keith Wiess in memory of her husband, the late H. C. Wiess, formerly vice-chairman of the board of trustees of the Institute. Mr. Wiess was also a member of the corporation of the Massachusetts Institute of Technology, and a charter trustee and permanent member of the board of Princeton University. It is expected that the chair will consist of a full professor of geology and two associates, and will be concerned particularly with the field of marine geology.

European Association of Exploration Geophysicists

THE inaugural meeting of the European Association of Exploration Geophysicists was held on December 14, 1951, at The Hague in the Royal Netherlands Institute of Engineers. On the following day the president, Mr. A. van Weelden, gave an address to members on geophysical activities in Western Europe during 1946–51, and six papers were read. The Association, which was formed during the previous June at The Hague when the Third World Petroleum Congress was held there, at present consists of more than three hundred geophysicists working in twelve countries in Europe and also in East Africa; the European countries are Belgium, Finland, France, Germany, Ireland, Italy, the Netherlands, Norway, Spain, Sweden, Switzerland and Great Britain. The headquarters of the Association are at 30 Carel van Bylandtlaan, The Hague. The membership subscription is 12 guilders (24*s.*) a year. Its council members are as follows: *President*, Mr. A. van Weelden, director of research, De Bataafsche Petroleum Maatschappij (Royal Dutch/Shell Group); *Secretary-Treasurer*, Dr. B. Baars (Netherlands); *Vice-President*, Dr. D. T. Germain Jones (Great Britain); *Members*, Dr. A. A. Fitch (Great Britain), Mr. L. Migaux (France), Dr. E. G. Hedström (Sweden) and Dr. A. Schleusener (Germany).

Radiography and the History of Art

A LECTURE was given on January 31 at the Institut Français du Royaume-Uni, South Kensington, London, by Mme. Magdeleine Hours on "La Radiographie des Peintures et l'Histoire de l'Art"; Mr. F. I. G. Rawlins, scientific adviser, National Gallery, was in the chair. Mme. Hours has been head of the Laboratory Departments at the Musée du Louvre, Paris, since 1949. In the course of her lecture, Mme. Hours pointed out that the Laboratory of Scientific Studies at the Musée du Louvre is at the disposal of all the departments of the Museum, but that she proposed to discuss only work carried out by the Art Department. When a picture is sent to the Laboratory, it may be for the purpose of preservation or for the purpose of an examination from the point of view of the history of art. So far as preservation and restoration are concerned, Mme. Hours thought the British public is already familiar with the scientific technique for the control of restoration. If opinions on this matter differ strongly, it is because of their subjectivity—the methods of control are the same in France and in England—only the interpretation of records is different and this depends a lot on the pictures concerned. Mme. Hours wished in particular to direct the attention of historians of art to the help which can be given by scientific methods, and more particularly by radiography and infra-red radiation, in providing an intimate knowledge of masterpieces, through the study of the rough sketches, the substructures of the painting, repaintings and so on. The records in the Laboratory of the Musée du Louvre, which number about ten thousand, would enable many false attributions to be rectified and solve numerous technical problems. International acceptance of these records, and exchanges between the chief museums, would enable the art critic to improve his methods of investigation and to re-create the various stages in the gradual construction of masterpieces. Mme. Hours has in preparation an international bibliography of the radiography of works of art and also a book on the scientific methods used in the Laboratory of the Louvre.

W. H. Hudson's Works

IT is good to see that a new uniform edition of the works of W. H. Hudson—"Nature in Downland", "A Hind in Richmond Park" and "The Purple Land"—has recently been published (J. M. Dent and Sons, Ltd.; 7*s.* 6*d.* each volume). Hudson is remarkable not only for his close observations on birds, beasts and the human race but also for the beauty of his prose. He wrote in such a way that each successive generation finds enlightenment and pleasure in his works. He had a passion for freedom

in wild creatures; a caged bird was to him the source of compassion and anger. When the second wife of the late Viscount Grey of Fallodon—Lady Glenconner, renowned for her beauty and her charm—went to Fallodon, she set up there an aviary of exotic and beautiful birds. These birds, having never known freedom, were as contented as the full-winged ducks which haunted Lord Grey's ponds and came to his hand to be fed, some of them even flying on to his head without fear and with great skill. One day Lord Grey, talking of Hudson and of his love of birds, said, pointing to the aviary, "I wonder what Hudson would have thought of this". A pause, and then, with a twinkle in the statesman's eye, he added, "I don't think he would have liked it". Hudson was never satisfied with his books. He once told a great friend of his that he was not pleased even with that classic, "Green Mansions". Yet to many that book is Hudson's best. There are few alive now who remember Hudson, but that small band still recall his rare and forceful personality.

Evolution, Education and Christian Belief

The British Social Biology Council has performed a useful service in publishing reprints of two important lectures delivered at a conference which it helped to arrange a year ago. In the first booklet, Dr. Julian Huxley pleads for the inclusion of the great generalizations of evolutionary biology in all courses of general education. Some understanding of evolution, he suggests, is indispensable to the answering of the three perennial questions which are always asked by human beings: What are we? What sort of world do we inhabit, and in what sort of relation do we stand to that world? The teaching of evolution provides the best transition between physico-chemical science and the humanities, and, of all branches of knowledge, evolution alone can adequately indicate man's place and destiny in Nature. In the second booklet, Dr. W. H. Thorpe examines the significance of Christianity from the point of view of evolution. Many religious men find it intolerable to accept a belief in natural selection as the main agent of evolutionary change. Dr. Thorpe considers their objections and arrives at the conclusion that "science and a progressive Christian faith are and ever will be indispensable to each other". The reprints may be obtained from the British Social Biology Council, Tavistock House South, Tavistock Square, London, W.C.1, price 1*s*. each.

Scenery in Wales

By means of an attractively illustrated booklet, the National Museum of Wales has made a praiseworthy attempt to interest Welsh people in the nature and origin of the scenery of their native land. Wales, of course, has such a range of old and new rock-structures that the compilers of the booklet have had some difficulty in deciding what to include. To appeal to as wide an audience as possible they have included commonplace features rather than famous beauty spots; these typical features can be matched in character if not in detail in many parts of Wales. They include the outcrops of limestone and shale exposed on Porthkerry Beach, the weird shapes assumed by ancient volcanic rocks near Trefgarn, alabaster in the Triassic marls in cliffs at Penarth, the peculiar effects of bedding and jointing at the Wash, near Flunston, inclined strata at Broadhaven cliffs, the effect of joints upon the face of a cliff and the way in which pebbles are formed. Other photographs include one of a peat bog, opencast coal-mining, a glaciated valley, the path of a glacier, a meandering river and the formation of stalactites and stalagmites. This attractive and instructive booklet could be widely used in Welsh and other schools; it may be obtained from the Museum, price 2*s*. 6*d*.

Use of Dermestid Beetles for Cleaning Mammalian Skeletons

In the November issue of the *Museums Journal*, E. M. O. Laurie and J. E. Hill describe the operation of cleaning mammalian skeletons by the use of Dermestid beetles. The species used is *Dermestes maculatus*, and the colonies are kept in the dark in large glass-jars at a temperature of about 75–80° F. (23·9–26·7° C.). A new colony is started with twelve beetles and twelve larvæ and is provided with the carcass of a rat, or some other small mammal. The colony will take about one month to attain working strength. The skulls to be cleaned are first skinned, brain, eyes and tongue are removed, and then air-dried for twenty-four hours. If the skulls are old, they should be soaked for twenty-four hours in a solution of 'Marmite'. Dermestids will also clean skulls and bones that have been preserved in alcohol, provided that they have been washed in running water to remove as much alcohol as possible. When the bones are clean, they are treated with 0·880 ammonia (diluted with its own volume of water) and then with water. Finally a stream of water is used for removing odd pieces of flesh and cartilage. Full details of this labour-saving technique are given in the paper, which will be welcomed by all museum curators when it is appreciated that by this method forty skulls can be cleaned, soaked and dried in six days for the expenditure of only three man-hours.

Radioactive Tracers in Metallurgical Research

Radioactive isotopes of most elements, with suitable characteristics to permit their use as tracers, have now been available, in almost limitless quantities and at relatively low cost, for some four years. Although the biological and medical research workers remain the predominant consumers, the extension of the applications of these useful materials to the industrial and technical fields is steadily increasing. A recent publication by the Ministry of Supply, entitled "Radioactive Tracers in Metallurgical Research" (pp. 56; London: H.M.S.O., 1951; 1*s*. 9*d*. net) describes their application to one of these fields. The booklet has been written by W. S. Eastwood, W. G. Marley, H. M. Finniston and A. E. Williams, who are all at the Atomic Energy Research Establishment, Harwell, and are actively involved in such studies. In common with most books dealing with radioactive tracers, three out of the four chapters deal with the fundamentals of radioactivity, its measurement and the health hazards presented by the use of radioactive substances. The concise treatment of radioactivity in the first two chapters makes the booklet attractive to all technologists anxious to obtain a necessary minimum knowledge of the fundamentals of tracer methods. The concluding chapter on health hazards should help to convince the cautious industrialist and his research director that tracer investigations may safely be undertaken in most situations if reasonable care be taken, and if competent staff are employed.

The shortest chapter is devoted to the titular subject. It is curious to note that nearly half the forty-odd references cited belong to the period before pile products became available. On the other hand, it may be significant that several of the possible applications described have already been employed since the publication of this booklet. Similar booklets covering the other important fields of technical applications of tracers would be welcome.

British Contribution to Television

THE Institution of Electrical Engineers is arranging a convention on "The British Contribution to Television", to be held in London during April 28–May 3. The convention will be divided into nine sessions, as follows: *Opening ceremony*, followed by an introductory survey paper by Sir Noel Ashbridge; *Historical*, devoted to a paper showing the evolution of television from the end of the nineteenth century to the opening of the regular B.B.C. high-definition service in November 1936; *Programme origination*, covering cameras, camera channels, studio lighting, film scanners, etc.; *Point-to-point transmission*, permanent and temporary cable and radio links, television-transmission measuring equipment, etc.; *Broadcasting stations*, vision transmitters and techniques, aerials and feeders, etc.; *Propagation*, ionospheric influences in television reception, selection of television transmitter sites, etc.; *Receiving equipment*, (1) receiver circuit techniques (time-bases, scanning systems, interference and its suppression, etc.), and (2) cathode-ray tubes and valves (design factors, life testing, etc.); *Non-broadcasting applications*, large-screen television design problems, medical applications, film-aids, television wire broadcasting, etc.; and *System aspects*, fundamental aspects of colour television, test equipment for television systems, subjective aspects of viewing, contrast, etc. Altogether it is expected that between sixty and eighty papers will be submitted to the convention. These papers will be available as advance proofs some time during April, and after the convention they will be published, together with discussion of them, in four issues, Nos. 17–20, of Part IIIA of the *Proceedings* of the Institution. During the convention there will be a number of demonstrations and excursions to places of technical interest. Further details can be obtained from the Secretary of the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2.

Postgraduate Studies in the Universities

IN a statement at a meeting of the Court of the University of Leeds on December 19, the vice-chancellor, Mr. C. R. Morris, referring to the increasing number of postgraduate students, claimed that in several fields of study and research original inquiry could be conducted more profitably in the University of Leeds than anywhere else. He said that the quality of students offering themselves for admission to these departments is also being maintained, and for some departments it has improved very greatly during the past twelve years. He thought, however, that it could improve still further; young men and women do not even yet sufficiently realize the importance, or the significance, of the fundamental scientific inquiries proceeding in many great university departments and commonly thought of as applied sciences or technology. Even during the economic stringency, he hoped that this work would continue to be developed. The universities are also the great guardians of standards on first and last questions, however, and while the University of Leeds does not aim at covering every small part of established scholarship, it does attempt to maintain strong and vital work inside the University in all the established disciplines of Western learning. Mr. Morris believes that the future of Britain as a great nation, and its future eminence in the sciences themselves, depend upon the maintenance of the high tradition of a university in which all the great fields of human knowledge and speculation are represented in strength.

Colonial Service: Recent Appointments

THE following appointments have recently been made in the Colonial Service: T. Y. Watson (deputy director of agriculture, Uganda), director of agriculture, Uganda; A. Huddleston (geologist, Kenya), deputy director, Geological Survey Department, Gold Coast; J. F. F. Callear (veterinary officer, British Guiana), senior veterinary officer, British Guiana; J. A. Fraser (senior forester, Uganda), superintending forester, Tanganyika; J. R. O. Humphries (senior inspector of produce, Department of Agriculture, Gold Coast), chief inspector of produce, Department of Agriculture, Gold Coast; I. G. John (meteorological officer, Federation of Malaya), assistant director, Meteorological Service, Federation of Malaya; D. Jones (assistant meteorological officer, Nigeria), meteorological officer, Nigeria; D. McPherson (assistant meteorological officer, Nigeria), meteorological officer, Nigeria; T. N. Middleton (forester, Kenya), superintending forester, Tanganyika; B. W. Thompson (scientific officer, Hong Kong), meteorologist, East African Meteorological Service; R. A. Bull, plant pathologist, Nigeria; G. H. Liddle, geologist, Water Development Department, Tanganyika; P. G. Morris, geologist, Nigeria; Dr. R. C. Muirhead-Thomson, principal scientific officer (malariologist), Gold Coast; N. M. Noble, veterinary officer, Sierra Leone; W. Pratt, veterinary officer, Kenya; J. D. Turton, veterinary officer, Gold Coast; E. M. Clegg, soil scientist, Northern Rhodesia; H. Davies, assistant conservator of forests, Nigeria; R. V. Holme, senior pasture research officer, Kenya; G. J. H. McCall, geologist, Kenya; F. S. McCullagh, biologist, Medical Department, Gold Coast; J. Sissons, assistant meteorologist, West African Meteorological Service, Gold Coast; W. Yates, laboratory superintendent, West African Institute for Trypanosomiasis Research.

Announcements

H.R.H. THE DUKE OF EDINBURGH has been elected an Honorary Fellow of the Royal Institute of Chemistry; this is the first such election to be made.

THE Hon. G. J. Bourke has been appointed land agent to the Nature Conservancy.

IN order to avoid exchange difficulties, financial agents have been appointed in various countries to whom members of the International Association for Plant Taxonomy may send annual subscriptions and payments for publications other than *Taxon*. The annual subscription of 3 dollars is stabilized at £1 1*s*. for the United Kingdom and British overseas territories and should be sent to Mr. A. A. Bullock, Herbarium, Royal Botanic Gardens, Kew, Surrey. Cheques should be crossed "a/c I.A.P.T.".

INTERFERENCE WITH THE FORMATION OF A NUCLEOPROTEIN COMPLEX BY RADIOMIMETIC COMPOUNDS

By Dr. PETER ALEXANDER

Chester Beatty Research Institute, Royal Cancer Hospital, and the Department of Chemistry, Imperial College of Science and Technology, London

'RADIOMIMETIC' compounds such as sulphur- and nitrogen-mustards, epoxides, ethylene imines and sulphonic acid esters can all be considered as alkylating agents which readily esterify anions. It has also been established that, in general, only compounds containing more than one reactive group per molecule show a high degree of biological activity and that the corresponding monofunctional substances, if active at all, often require 50–100 times the concentration necessary with the polyfunctional compounds[1–5].

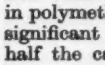
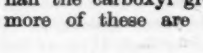
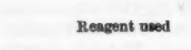
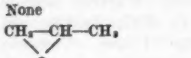
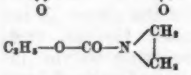
It seemed reasonable to expect these compounds to react with the ionized phosphate groups of nucleic acid, and Elmore *et al.*[4] found that sulphur-mustard brought about such a reaction. It has been found in the present work that representative examples of the other types of radiomimetic compound behave likewise and esterify the phosphate groups of the sodium salt of thymus nucleic acid in dilute solution (0·2 per cent). Since the nitrogen-containing alkylating agents are bases which combine with acid, it is difficult to determine the degree of esterification from the titration curve of nucleic acid. The total number of anionic groups (that is, ionized phosphate) in the macromolecule can be determined by measuring the quantity of basic dye taken up at *p*H 7. A satisfactory technique was to contain the thymus nucleic acid (kindly provided by Drs. J. A. V. Butler and K. A. Smith) in a semi-permeable membrane surrounded by a solution of methylene blue and to determine the change in concentration of the dye solution. In these dilute solutions, errors due to Donnan membrane effects are negligible, and the values thus obtained for the equivalent weight of the thymus nucleic acid are in good agreement with that calculated from the phosphorus content and the titration curve. An essentially similar technique was used for measuring the quantity of the protamine salmine which can combine with the nucleic acid, since the former can readily diffuse through 'Cellophane'.

The phosphate groups are esterified at approximately similar rates by the mono- and poly-functional compounds in each series, and it is unlikely, therefore, that it is this reaction alone which is biologically significant. It is generally accepted that the phosphate groups of nucleic acid are involved in the formation of the nucleoprotein complex, and the influence of the reaction of thymus nucleic acid with the radiomimetic compounds on the combination with salmine was therefore studied.

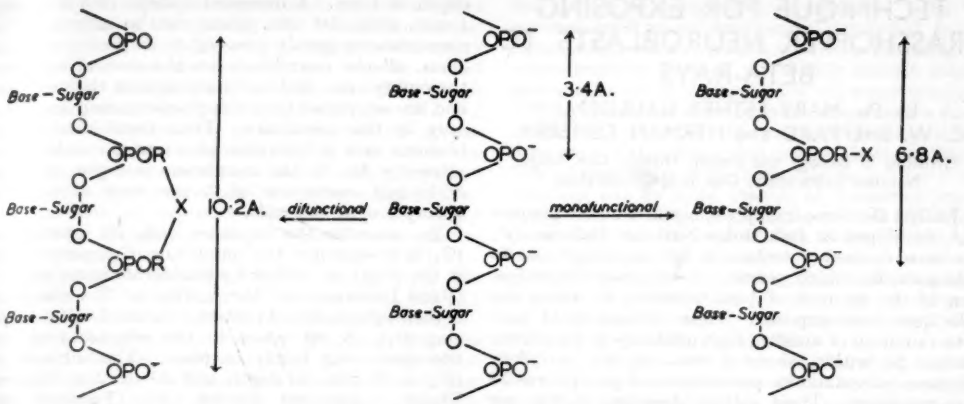
It was found that the affinity of the nucleic acid for protamine was not greatly decreased after reaction with monofunctional compounds during which up to 40 per cent of the phosphate groups had been esterified, whereas a similar reaction with polyfunctional compounds produced a very substantial reduction. In the accompanying table results for four pairs of mono- and poly-functional compounds are shown in which the degree of esterification was approximately the same. All these polyfunctional substances produce typical radiomimetic effects, whereas the monofunctional derivatives show no activity in the intact animal[7].

The full affinity of the nucleic acid for protamine after treatment with epoxide can be restored by mild alkaline hydrolysis, which brings about saponification of the phosphate ester groups. Since the products of the reaction between alkylating agents and the amino groups of the nucleic acid bases are not alkali-labile, it can be concluded that the interference with the formation of the nucleoprotein complex results from the reaction with the phosphate groups.

If the bi- or poly-functional compounds react with neighbouring phosphate groups, the reaction product can be seen from the accompanying reaction scheme, which is based on the Astbury model[8] of repeating nucleotide units at every 3·4 Å. It has been established, notably by the work of Kuhn *et al.*[9], that the electrostatic repulsion between anions in the molecule of a poly-electrolyte such as polymethacrylic acid causes the molecule to be fully extended, so that it cannot assume a randomly coiled configuration under Brownian motion. The repulsion between the anions in polymethacrylic acid is sufficient to ensure that no significant coiling of the molecule takes place when half the carboxyl groups are un-ionized, but when more of these are blocked so that the distance

Reagent used	Per cent esterification	Ratio of salmine combined with nucleic acid before and after reaction
None	0·0	1·0
	25	0·8
	32	0·4
	30	0·8
	30	0·5
$CH_2.SO_2.O(CH_2)_3.CH_3$*	26	0·9
$CH_3.SO_2.O(CH_2)_3.O.SO_2CH_3$*	28	0·4
$(CH_3)_2N.CH_2CH_2Cl$	31	0·7
	40	0·2

* See ref. No. 5.



between charged groups is greater than that between alternate repeating units, the molecule loses its rigidity.

The change in physical properties of nucleic acid after reaction with the polyfunctional compounds may result from changes in the shape of the nucleic acid molecule, which is known to be highly asymmetric when in solutions as its sodium salt. It is suggested that the repulsion between charged groups is sufficient to maintain the molecule fully extended even when isolated phosphate groups have been esterified by reaction with a monofunctional compound, but that after blocking two adjacent anions with a bifunctional compound the distance separating charged groups is too great for electrostatic effects to keep the molecule rigid at this point. If several such reactions have occurred along the length of the macromolecule, this may then be far from linear in solution, even though the deviations at any one point may be small. It follows from this hypothesis that a change in the shape of the nucleic acid molecule will only be brought about by monofunctional compounds after extensive reaction, since with excess of phosphate groups it is unlikely that reaction on neighbouring sites will occur. This may explain why it may be necessary to use 50–100 times the concentration of a monofunctional derivative to achieve a biological effect comparable with that produced by a polyfunctional compound.

Timmis[10] has suggested that the biological action might depend upon the alkylation of an essential primary amino to a tertiary amino group, and that this would be achieved much more easily when a suitable bifunctional compound reacted to yield a ring compound than when two molecules of a monofunctional compound were in reaction. The spatial configuration required by a compound to esterify two adjacent phosphate groups or to form a ring with a nitrogen atom may be related, and the relationship found by Timmis between the disposition of the two functional groups and biological activity in a series of aliphatic esters of methanesulphonic acid lends support to both hypotheses. For example, after partial esterification of nucleic acid with $CH_3SO_2OCH_2C \equiv CCH_2OSO_2CH_3$, the affinity for protamine is only slightly reduced. This compound, which cannot form a ring on reaction with an amino group or esterify adjacent phosphate groups, is inactive in the intact animal.

In general, the tendency for inter-molecular association is greater between elongated than between coiled macromolecules. A change in shape of the nucleic acid molecule after reaction with a polyfunctional compound which does not occur after a corresponding treatment with a monofunctional compound may explain the observed difference in affinity for protamine. It is interesting to speculate whether the biological effects of the radiomimetic compounds can be ascribed to the interference with the formation of a nucleoprotein complex, or if a change in shape of nucleic acid alone may be responsible. Coiling of the macromolecule would be expected to interfere with protein synthesis if the suggestion of Haurowitz[11] is accepted that the role of nucleic acid is to maintain the 'template protein' in an expanded state during biosynthesis. The growth-inhibiting activity of stilbamidine is thought by Kopac[12] to be due to an interference with the combination of nucleic acid with protein, and there may therefore be an unexpected similarity in the mode of action of the amidines and the alkylating agents discussed here.

I would like to express my thanks to Prof. A. Haddow for his interest and encouragement. This investigation has been assisted by a special grant from the Anna Fuller Fund and by grants to the Royal Cancer Hospital and Chester Beatty Research Institute from the British Empire Cancer Campaign, the Jane Coffin Childs Memorial Fund for Medical Research and the National Cancer Institute of the National Institutes of Health, U.S. Public Health Service.

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TECHNIQUE FOR EXPOSING GRASSHOPPER NEUROBLASTS TO BETA-RAYS

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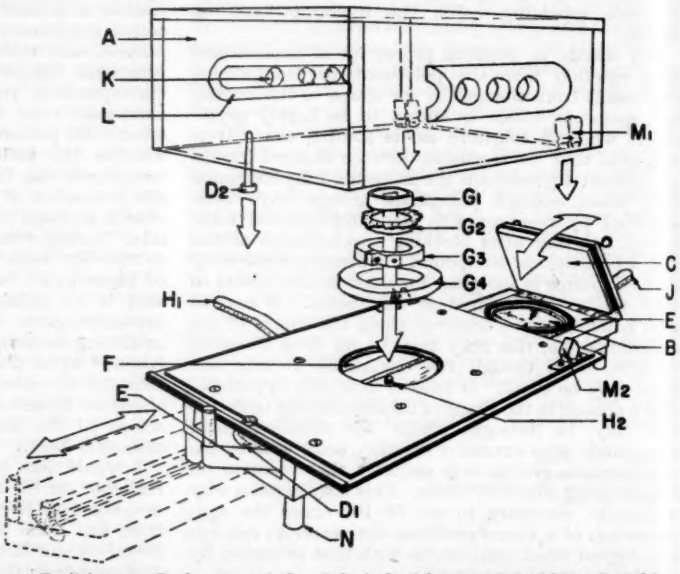
USING the three-inch phosphorus–bakelite plaques developed at Oak Ridge National Laboratory[1], we have devised a technique for exposing cells to beta-particles which permits an accurate determination of the amount of beta-radiation to which the cells have been exposed. These plaques yield pure beta-radiation of uniform high intensity at the plaque surface to within about 7 mm. of the periphery (distance of maximum penetration of phosphorus-32 beta-particles). Their surface dose-rate in rep. per hour can be accurately measured with an instrument designed and calibrated by Sheppard and Abele[2].

The large neuroblasts (25 μ) of the embryo of the grasshopper *Chortophaga viridifasciata* are particularly amenable to treatment with beta-radiation because (1) they lie in a single layer at the ventral surface of the embryo and can be brought into close contact with a plaque, thereby eliminating the uncertainties connected with extended depth–dose calculations; (2) they can be grown in artificial culture medium and therefore can be covered with a thick aqueous layer during irradiation. This latter condition is especially advantageous in taking into consideration scattered radiation. The aqueous layer has essentially the same scattering and absorption properties as the cells; therefore the troublesome corrections for boundary effects encountered in dosage estimation for cells irradiated in air can be eliminated. Further, the aqueous layer is closely similar in its scattering and absorption properties to the polystyrene electrodes used for the extrapolation chamber with which the plaques are calibrated[1]; thus the percentage of the total dose attributable to radiation scattered back from the culture medium to the cells is almost exactly the same as that contributed by scattered radiation from the polystyrene to the calibration measurement of the plaque.

Fourteen-day-old grasshopper embryos are dissected out of the eggs in artificial culture medium[3] and separated from the embryonic membranes and yolk. The appendages are removed to expose the ventral surface, and the head and abdomen cut away to reduce the tissue mass. The dissected embryos are then transferred to the centre of an exposure dish (*G*) and placed, ventral surface down, on the thin membrane which forms the bottom of the dish. The dish is filled with culture medium to a depth of 1 cm. A dissected embryo (1·5 mm. long, 1 mm. wide, 0·5 mm. thick) can be affixed to the membrane by gently pressing on its freshly cut ends. Thus, all the neuroblasts on the ventral surface of the embryo can be held firmly against the membrane and are separated from the plaque during irradiation only by this membrane. From depth–dose determinations in a polystyrene phantom the reduction in intensity due to the membrane is 5 per cent. An additional correction of 2 per cent is made for absorption in the cells.

To assemble the exposure dish, an internal ring (G_3) is pressed into the clamp ring (G_2), carrying with it the 0·001-in. rubber hydrochloride membrane (G_5) (Reed Laboratories, Akron, Ohio). The clamp ring is then tightened and pressed into the 'Lucite' adapter ring (G_4). A set screw in the adapter ring holds the clamp ring firmly in place. The internal ring (G_3) is 12 mm. in depth and 33 mm. in diameter. These dimensions exceed the Feather range (maximum penetration) of phosphorus-32 beta-rays in water.



A, 'Lucite' cover; *B*, plaque receptacle; *C*, lead–aluminium receptacle shield; D_1, safety latch; D_2, pin for releasing safety latch; *E*, slide which carries plaque; *F*, exposure opening; *G*, exposure dish; G_3, ring for holding rubber hydrochloride membrane, G_5, in the clamp ring, G_2; G_4, adapter ring; H_1, H_2, lever for pushing plaque against bottom of exposure dish; *J*, lever for ejecting plaque; *K*, air holes; *L*, air-hole shield; M_1, M_2, clamp for securing 'Lucite' cover to exposure platform; *N*, platform support

The apparatus used for making the radiation exposure is designed to provide maximum protection to the operator. (The specific mechanical design of the exposure chamber represents a synthesis of the ideas of several investigators in this laboratory during the past three years and should not be construed as being wholly conceived by us.) The 'Lucite' cover (*A*) is removed, and the remainder of the exposure chamber is placed behind a ¼-in. 'Lucite' shield[1]. A plaque of known surface intensity is then placed with a pair of tongs in the receptacle (*B*). The lead-aluminium cover (*C*) is closed and the apparatus is removed from behind the shield. The safety latch (D_1) prevents the slide (*E*), which holds the plaque, from moving and carrying the radioactive plaque to the exposure opening (*F*). The exposure dish (*G*)

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containing the embryos immersed in culture medium is then seated in the opening (*F*). When the 'Lucite' cover (*A*) is replaced, the pin (D_2) releases the safety latch (D_1) so that the slide (*E*) can now be moved freely. For exposure of the cells, the slide (*E*) is pulled out as far as possible, and the lever (H_1, H_2) is depressed immediately to push the plaque against the bottom of the exposure dish. At the end of the exposure, the lever is released and the slide is pushed back. The movements can be synchronized so that the duration of exposure can be very accurately regulated. The ejecting lever (*J*) facilitates removal of the plaque.

The principal features which contribute to the protection of the operator are the 'Lucite' shield (*A*), the lead–aluminium lid (*C*), the 'Lucite' enclosure[1], in which the plaque is transferred to and from the exposure chamber, and the safety latch (*D*), which holds the radioactive plaque in a safety position under the lid (*C*). The lid (*C*) over the plaque receptacle (*B*) consists of a piece of lead between two sheets of aluminium—the aluminium stops the beta-particles and, being of low atomic number, generates few *Bremsstrahlen*, which are easily absorbed by the lead.

Following irradiation, the embryos can be transferred to cover slips in hanging drops of culture medium and sealed over depression slides for microscopic study of the neuroblasts. With radiation-induced mitotic inhibition serving as criterion of effect, the method has given satisfactory results in that all cells treated have been uniformly affected. A detailed report of the results will appear elsewhere.

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SELECTIVE PHYTOTOXICITY OF SYNTHETIC GROWTH REGULATORS IN WHEAT, OATS AND BARLEY

THE initial phase of the development of 2 : 4 dichlorophenoxyacetic acid (DCPA or 2,4-D) and 2-methyl-4-chlorophenoxyacetic acid (MCPA) as selective herbicides took place in England between 1943 and 1945. Because of the limitations of wartime, the experiments were confined to the testing of simple inorganic salts, coupled with methods of application which were within the capacities and performance of existing spraying machinery. In consequence, the first recommendations for the use of these synthetic growth regulators in cereal crops centred around the sodium salts applied as a relatively coarse spray of some 100 gallons of aqueous solution per acre.

Within two years cereals were being extensively sprayed in Great Britain and elsewhere. In the United States and Canada, shortage of water on the farm was often a major factor in hindering the more extended use of 2 : 4 dichlorophenoxyacetic acid, and the necessity to economize water led to the development of inexpensive machines capable of applying a few gallons of spray solution per acre. This 'low-volume' method of application demanded in turn formulations which could be applied in relatively high concentrations, such as the readily soluble ethanolamine salts or esters, applied in oil-water emulsions.

With these twin developments, there came a further major expansion in the acreage treated, first in America and then from 1948 onwards in Great Britain. The change-over from high-volume to low-volume spraying was so rapid that in all countries practice completely outstripped principle, since in the interval there had not been time enough to establish how far the phytotoxic properties of amines and esters differed from those of the original sodium salts, or whether the differences in the mean droplet size associated with varying the volume of application brought about differential effects.

To the research worker it is not, therefore, surprising that with the extended use of the newer techniques and formulations there has been some variability of results. Perhaps the most significant feature is the liability of the cereal crop to be injured, the damage showing itself most clearly in the abnormal inflorescences produced. It was against this background that a symposium on "The Selective Phytotoxicity of 2,4-D and MCPA in Wheat, Oats and Barley" was arranged by the Crop Protection Panel of the Agricultural Group of the Society of Chemical Industry and held on November 8 at the Royal College of Science.

Dr. W. E. Ripper (Pest Control, Ltd.) discussed the results of recent experiments relating to the effects of 2 : 4 dichlorophenoxyacetic acid and 2-methyl-4-chlorophenoxyacetic acid on a susceptible dicotyledonous species, namely, mustard. When the sodium salts are applied, formative effects such as epinasty appear first in plants treated with the latter. If rain falls shortly after treatment, much less injury occurs in the plants receiving the former. The replacement of sodium by an amine base leads to some increase in toxicity, but the differences are not very great; neither does the effect of rainfall vary greatly with these changes. When spray droplets on the leaves are allowed to dry out, examination under the microscope shows that crystals of the sodium salt of the dichloro compound are formed much sooner than those of the sodium salt of 2-methyl-4-chlorophenoxyacetic acid, while in the case of the amines at normal air humidities crystallization rarely occurs.

Mr. K. Carpenter (May and Baker, Ltd.) emphasized that in a mixed weed population competition between species is a factor which must be taken into account in interpreting the effects of any spray treatment on the individual species. In the mixed weed flora investigated, the ethyl ester of 2 : 4 dichlorophenoxyacetic acid applied in an oil emulsion was in general more toxic than aqueous sprays of the trimethylamine salt, but the differences were dependent on the species.

In Europe, Great Britain and America, a wide range of formulations of 2 : 4 dichlorophenoxyacetic acid has been employed in investigations relating to cereals, while 2-methyl-4-chlorophenoxyacetic acid has been tested almost entirely as the sodium salt. Therefore, an assessment of their comparative effects based on the same type of formulation is often not possible, while the further difficulty arises that in different countries the relative interest in these two herbicides has greatly varied. These difficulties were pointed out by Dr. H. P. Allen (Plant Protection, Ltd.) in his general review of the direct effects of these synthetic growth regulators on cereal crops.

There is evidence that cereal crops differ in their liability to injury; oats appear to be the most susceptible, barley is intermediate and winter wheat the most resistant. Dr. Allen's experiments on barley have indicated that with a change-over from the sodium salts to the *n*-butyl esters, the greater toxicity to the crop of 2 : 4 dichlorophenoxyacetic acid is accentuated. Mr. J. Fryer (Agricultural Research Council Unit of Experimental Agronomy, Oxford) stressed that any attempt to define the effects on cereals of formulation and volume of application demands an extensive field programme covering several years. A preliminary examination of the results for the 1951 trials on barley suggests that the degree of injury brought about by the application of the triethanolamine salt of 2 : 4-dichlorophenoxyacetic acid at the rate of 0·5 lb. of the acid per acre is roughly equivalent to the effects produced by the sodium salt of 2-methyl-4-chlorophenoxyacetic acid at 2 lb. per acre. Spraying at an early stage prior to the formation of tillers produces the largest number of abnormalities; but even when the proportion of abnormal ears is exceptionally high, this does not necessarily lead to any appreciable loss of yield, although the quality of the grain may be affected.

K. Holly (Agricultural Research Council Unit of Experimental Agronomy, Oxford) pointed out that in commercial practice it is commonly held that a specific amount of these two herbicides is required per acre to destroy a particular weed species and that the volume of solution applied is of little importance. Field investigations at Oxford have revealed a great variability in the effects of changing volume-rate on different species and between different experiments. From experiments in the greenhouse it is already evident that the amount of spray solution retained by the shoot is dependent on the volume of solution applied, and that with the test plants used (mustard and barley) there were marked specific differences in retention as the volume changed. Since a change of droplet size could also affect penetration into the leaf and since the effects of decreasing droplet size on penetration tended to be the reverse of those on retention, it was not surprising that in the field variable results were obtained. Dr. E. K. Woodford (Agricultural Research Council Unit of Experimental Agronomy, Oxford) stated that in his opinion the greater toxicity of the dichloro compound in the field cannot be satisfactorily accounted for in terms of retention and penetration. On the other hand, the evidence, although surprisingly scanty, indicates that at cell-level there is little difference between the two compounds in their inherent toxicity. One is therefore left with the conclusion that the major difference between the compounds is a question of transport or persistence within the plant.

Lastly, Prof. L. J. Audus (Bedford College, London) dealt with some of the factors relating to the breakdown by micro-organisms of 2 : 4 dichlorophenoxyacetic acid, 2-methyl-4-chlorophenoxyacetic acid and 2 : 4 : 5-trichlorophenoxyacetic acid in the soil. In perfusion experiments there is first a lag phase when no breakdown occurs followed by a rapid rate of decomposition. The lag phase is shortest for the dichloro compound; complete breakdown of the trichloro compound has not been found even after a period of months. Once the phase of rapid decomposition has been reached, there is no subsequent lag period when further additions of the dichloro or methyl compound are made. Since the decomposition can be inhibited by the addition of sodium azide, it is clearly due to micro-organisms; in fact, an organism belonging to the *B. globiformis* group can be readily isolated. So far attempts to grow this organism in culture media have not been successful, and the further elucidation of the mechanism of breakdown is thereby being hindered.

G. E. Blackman

INSTITUTION OF GAS ENGINEERS

AUTUMN RESEARCH MEETING

THE seventeenth autumn research meeting of the Institution of Gas Engineers was held in London during November 27–28, 1951, under the presidency of Mr. J. H. Dyde.

A statement by Colonel H. C. Smith, then deputy chairman of the Gas Council, which opened the proceedings, outlined the progress which had been made with regard to the future organization of research in the gas industry. The Gas Council considered that its responsibility was primarily for fundamental research, and took the view that the gas industry's existing research body, the Gas Research Board, was not an appropriate machine for satisfying the duties imposed upon the Council by the Gas Act of 1948. Accordingly, a research advisory committee was appointed which, after reviewing existing investigations, recommended the establishment of research stations. Two such stations have now been formed, in London and Birmingham, under the direction of Dr. H. Hollings and Dr. F. J. Dent, respectively. In addition, continued Colonel Smith, the connexion between the gas industry and the University of Leeds is to be maintained through a joint committee of the University and the Gas Council. Finally, a small research liaison committee has been formed to ensure effective collaboration and co-ordination of the work.

A feature common to several of the technical papers presented later during the meeting was the successful application of new scientific techniques to the current problems of the gas industry. Thus, C. H. Lewis described a method of measuring coal travel in continuous vertical retorts which has the advantage over previous methods of being non-destructive, and hence applicable at any stage in the working life of a retort. A tally of radioactive cobalt is introduced into the coal charge at the top of the retort, and its position is determined at intervals during its descent by means of water-cooled Geiger counters placed in the combustion chambers.

Again, the high paramagnetic susceptibility of oxygen has been used as the basis of an instrument designed to record the oxygen content of a gas in the range 0–2 per cent by volume. A description of the instrument, which depends for its operation on the generation of a magnetic wind, was given by R. H. Griffith, who also presented some results obtained by its use for the automatic control of a catalytic plant for the removal of organic sulphur compounds from coal gas.

In the field of gas utilization, a better control of combustion processes, and improved heat transfer from flame gases, should follow from the wider application of experimental techniques adapted by W. A. Simmonds and M. J. G. Wilson for following the path of secondary air towards and into flames. Both the quartz-fibre anemometer and the powder method of flow visualization have been used for determining the flow of air towards small, radially symmetrical diffusion flames of several inflammable

gases. Experience has proved the powder method to be of more general application, and its use, in conjunction with *Schlieren* photography for locating flame boundaries, shows that the amount of air entrained by the above type of flame is approximately three times that required for complete combustion. About half the air required for complete combustion flows directly into the reaction zone, the remainder entering that zone by diffusion.

The satisfactory disposal of liquor effluents is a problem which has confronted the gas industry for some time, and one which has assumed greater importance recently as a result of increased gas production, greater sewage flow generally, and new legislation governing the prevention of river pollution. The urgency of the problem was emphasized in two papers dealing with the treatment of gas-works liquor.

C. Cooper and W. E. Bouch outlined a new method of effluent liquor purification in which the residual toxic matter in ammonia stills and other gas-works effluents is destroyed by nitric acid and nitrous acid. Inorganic salts such as ammonium thiosulphate and thiocyanate are converted into comparatively harmless substances, while the decomposition products of the acid are recovered for further use by simple oxidation with air. On the other hand, some nitric acid is lost as a result of its combination with any phenolic bodies present in the effluent.

The second paper, by W. H. Blackburn, T. G. Tomlinson and T. H. Summers, discussed the treatment of gas-works liquor in admixture with sewage in percolating filters. As part of a long-term investigation into the identification and estimation of the constituents of gas liquor, a typical liquor has been divided into a number of fractions and the effect of each fraction on sewage purification determined separately. A new method for the fractionation of the liquor, using methyl *iso*butyl ketone as solvent, was devised and four main fractions obtained, that containing phenols being further sub-divided by distillation. The greatest deterioration in the quality of a domestic sewage effluent was afterwards shown to be caused by the addition of two fractions, one containing thiocyanate, ammonia and organic substances not extracted from the liquor by the solvent, and the other containing carboxylic acids and 'humic acids'. Further, polyhydric phenols were shown to produce a greater deterioration in effluent quality than monohydric phenols.

Some aspects of the mechanism of the gasification of carbon by carbon dioxide and steam were discussed by J. D. F. Marsh. Laboratory experiments have shown that, when a sample of high-temperature coke is reduced by hydrogen and then treated with carbon dioxide at a temperature below that necessary for gasification, a reaction occurs producing carbon monoxide and a surface layer of adsorbed oxygen which can be removed as water vapour by subsequent treatment with hydrogen. If treated with carbon monoxide instead of hydrogen, most of the oxygen is removed as carbon dioxide; but on the reduced surface, carbon monoxide is then converted to carbon dioxide and carbon. These and other results are then used to elucidate the mechanisms for the reactions between carbon and carbon dioxide or steam.

Finally, the possibilities of recovering pure sulphur from gas-works spent oxide by extraction with toluene were discussed by F. A. Burden and W. B. S. Newling, while R. F. Hayman considered the application of flow visualization techniques to the design of small high-temperature, gas-fired furnaces.

THE MICROSCOPE IN INDUSTRY

IN Beck's microscope catalogue for 1865 there are engravings of what one supposes to have been typical subjects for the microscopist of that day. One of them is a beautifully drawn but revolting picture of a parasite "to be found in the follicles of the human skin, particularly about the nose. They are easily obtained by . . .". Nowadays the microscope serves a more utilitarian purpose, and we may enjoy instead a picture of a speck of oil being coaxed from a soiled textile fibre by a gentle detergent. This particular study was one of many demonstrations set out at a recent exhibition in London to show "How Industry is Using the Microscope". The exhibition, organized by the Royal Microscopical Society, was held at British Medical Association House on November 21 and was opened by the director of the British Scientific Instrument Research Association, Mr. A. J. Philpot.

The microscope, unlike other industrial instruments, was not conceived for industry, and its value there has only in the past few decades been widely recognized. The present extent of its application to industrial problems is shown by the fact that the forty-two contributors to this exhibition came from a wide range of industries: mining and power, agriculture and food, metallurgy, ceramics and glass, paper, rubber, fabrics and leather, paint, pharmacy, photography and industrial biology. Several branches of these industries were appropriately represented by their research associations. If the subjects of the display must be classified, it is safe to say that more than half the exhibits were of applications of the microscope to process control and to the investigation of well-established manufacturing processes. Textiles, leather and cosmetics have been made since the distant time when the advantages of being well clothed, well shod and beautiful were first realized; for the greater part of this time 'process control' has meant no more than feeling, smelling and looking at the fabric or the ointment. Now the man in charge is being offered the support of scientific instruments: the microscope is used to follow the progress of textile fibres, collagen fibres, paper and jute fibres, emulsions, dough, yeasts, metals and minerals through their traditional processes of manufacture. For some of the new products, such as antibiotics, control by microscopical examination is essential. The isolation by micromanipulation of single spores of approved character for the breeding of new lines of yeast and antibiotic-producing fungi (a technique strongly reminiscent of "Brave New World") was well demonstrated by photomicrograph and working apparatus. The micromanipulators responded to controlling movements with remarkable freedom from backlash.

In analysis, microscopy takes its place with X-ray analysis and the other non-destructive techniques, and it is particularly in this field that the electron microscope finds many applications. Diamond polishing powders, photosensitive grains, pigments, carbon black in rubber, and clay particles in minerals for the ceramic industry are near or beyond the limit of resolution of the light microscope, and examination of raw materials or products containing these particles is now a routine procedure with the electron microscope. As many of the electron micrographs showed, the image is enhanced by shadow-casting. The electron microscope seems to have made a present of

this technique to the light microscope, perhaps to counter any mistaken impression that there is rivalry between the two instruments. Some fine optical micrographs of metal-shadowed replicas of paint surfaces were displayed.

Analysis by microscopical examination is rarely a straightforward matter of immediate recognition of structure or crystal form but requires the building up of an index by correlation with the results of other methods of examination. This is true not only of the identification and estimation of the constituents of a product (the subject of several exhibits from the metallurgical, ceramic, textile, paper, biological and pharmaceutical industries), but also of the investigation of the causes of defects. This latter duty of microscopy was well demonstrated by an exhibit showing the methods used in examining the crystalline inclusions in glass. This exhibit, by the Glass Technology Department of the University of Sheffield, was supported by many photomicrographs and sections of identified crystal forms, which are often quite different in shape from the crystal growths in their free state. Such a bold and extensive display of the range of defects possible in a single product could perhaps only have been staged by an impartial body; so, to gratitude for the instruction received is added the prayer that the wrath of the glass industry may not have descended upon the University of Sheffield.

From accidental defect we may descend to adulteration and downright swindle. A most interesting exhibit by the Pharmaceutical Society of Great Britain showed how fraudulent substitutes for the basic crude drugs may be detected.

Metallurgy owes much to the microscope, and as new methods—phase-contrast, interference and electron microscopy—have been perfected they have naturally been applied to metallography, though perhaps 'naturally' is not quite appropriate for the last of these, since the electron microscope requires a transparent object; for examination at the highest magnifications the metallurgist must therefore rely on transparent replicas of the surface conformation. Among the several examples of replica technique was a photographic demonstration of the remarkable fidelity of reproduction by the replica; optical and electron micrographs of the same area of a metal specimen showed identical features, though the resolution of fine detail was clearer in the electron micrograph since at the magnification used (× 4,000) some empty magnification was being obtained with the light microscope.

Many special devices were on show, headed by the historic microscope specially ordered by the firm of Whitbread and Co. for Pasteur's use in his investigation of the brewing process. Three reflecting microscopes were shown, one with a long working-distance for use with a furnace; the other two were for infrared spectrometry, which has become a valuable method of micro-analysis. Several other exhibits of apparatus for special purposes and techniques for measuring physical quantities must, for lack of space, be passed over, but a final word must be spared to note the concentration of microscopical technique being brought to bear by the National Coal Board on the problem of disease due to airborne dust.

The exhibition was well attended, and it is to be hoped that further opportunities will be given to microscopists to display the versatility of their noble instrument.

K. M. Greenland

PROBLEMS OF THE LEFT-HANDED

STUDIES have been made of the probable 'handedness' of prehistoric man by investigating the various relics of his tools and weapons. It appears from the way they are carved that prehistoric man was preponderantly right-handed. The choice of one hand, usually the right but occasionally the left, and not either hand indiscriminately, is characteristic of man. It would seem that ambidexterity is an animal rather than a human characteristic. These and related problems have recently been discussed by M. M. Clark (*Health Education*, 9, No. 3; July 1951).

Clark suggests there is no adequate explanation why man should choose one hand and become proficient with it, while his animal ancestors usually used both. Nor can any adequate reason be put forward to explain men's preference for the right hand; and although to be left-handed in a right-handed society has numerous disadvantages, in spite of attempts to stamp it out in Britain, Greece, the United States and France, approximately 4–6 per cent of the population are still left-handed. Why should this be?

Left-handedness appears to be inherited; how is not known. In certain families there seems to be a high incidence of left-handedness. Some investigators have found that such families also have more than the usual number of twins, so that there might be some connexion between twinning and left-handedness.

That more males than females are left-handed seems to be agreed by investigators and raises the interesting question of whether this is the original distribution, or whether it is a result of the pressure of society. Are more boys than girls born with a tendency to left-handedness, or is it that, while girls are more willing to bow to convention, boys are more inclined to be independent, or stubborn? It would be revealing to carry out a detailed study of the personality traits of left-handed writers, and compare the results with the personality traits of those who were naturally left-handed, or had a tendency to left-handedness, but did not hold out against the pressure of society. Many difficulties lie in the path of such an investigation, most important of all being the difficulty of finding a reliable test which will measure native handedness. Existing tests do not enable us to distinguish truly right-handed people from those who are naturally left but for some reason use their right. There must be a considerable number of such cases.

The majority of infants prefer one hand to the other, if not at once, then within a few months after birth. It is clear that in a right-handed society the right will be preferred rather than the left. Thus, if a child is born slightly left-handed, the chances are that he will become right-handed. Imitation, training and the right-handed nature of everyday objects are all inducements to his adoption of the right hand.

An ambidextrous child, or rather one who has no preference for either hand, will quickly appear to be right-handed for similar reasons. These are children who could have been good with either hand. If everyone else had used the left, they, too, would probably have done so, and been equally successful.

There is another group which has been given little consideration until recently. Rather than ambidextrous, they might be described as 'ambisinistrous' or poor with either hand. They, too, will veer to right-handedness.

Thus, the left-handed writer will be only the extreme case of left-handedness.

The study of 'eyedness' has developed as an outgrowth of the study of handedness. Preference for one eye is not evident to the casual observer; but the majority of people are right-eyed, and the minority left-eyed, though there are far more people left-eyed than are left-handed.

To-day it is believed there is no connexion between eyed preference and handedness, though some believe that it is better to be right-eyed and right-handed or left-eyed and left-handed than of crossed dominance.

The preferential use of one foot is evident in leisure occupations involving kicking, hopping and the like. There is a trend similar to that in handedness, the majority being right-footed, and a small minority left-footed.

Various tests have been used in studies of handedness, and these seem to fall into five classes. These are tests for speed, which are devised to measure the relative speeds of the two hands; accuracy, where a measure is made of which hand is the more accurate in its movements during a controlled test situation; strength, in which early investigators used a dynamometer or some similar measure and compared the strength of the two hands; preference, which involves the finding of the "preferred" hand. A satisfactory method of deciding handedness preference is to decide on a limited number of important activities where one hand is used in preference to the other. The next stage is to devise tests whereby this preference can be measured. Preferably, this should be done without the subject realizing what is actually being tested, or results may be distorted. For example, one may wish to discover which hand a person uses in throwing. A question may not produce the true answer, especially with children. Alternatively, the investigator could say, "Take this ball and throw it. I want to see which hand you use". The danger here is that the child may choose one or other to oblige, or because he suspects that the investigator would like him to use it though it may not be the one he usually uses.

The third method is to say, perhaps: "Here are three balls. I want to see if you can throw them all into that basket". Here the investigator notes which hand is chosen.

The fifth type of test for handedness was devised about 1930 by Van Riper in the United States, who decided that an adequate test should fulfil certain requirements: it should show striking differences, and little overlapping; have a high degree of reliability; avoid so far as possible the skills susceptible to previous environmental training and show degrees of laterality if these exist.

His original test involved drawing a pattern with both hands at the same time on opposite sides of a vertical board.

The Van Riper 'laterality board' is an elaboration of that idea. The principle of the method is that, if a person is asked to draw a design with both hands at the same time, and is not allowed to watch what he is drawing, then one or other of the hands finds the task impossible and draws a mirror image of the design. This is the non-dominant hand.

This test appears to be able to pick out those who are natively left-handed, even if they have been forced to use their right. It is extensively used in America, and several clinics in Glasgow also possess the apparatus. An interesting development made possible by this test was the discovery of a group who might be termed equipoised. Though they use their right hand, it has not achieved a definite dominant lead over the other. This group may have considerable educational difficulties.

Much discussion has taken place about the connexion between speech and handedness, and more especially between "changed" handedness and stuttering. Discussion usually centres on whether or not a left-handed child should be forced to use his right hand and the possible dangers resulting from such action. It appears doubtful whether the mere fact of changing from use of the left to use of the right hand will, in itself, be sufficient to cause stuttering. The danger seems to arise from the methods adopted in bringing about the change, and the emotional stress which usually results. The old-fashioned method of tying the left hand out of reach or of hitting it every time the child attempts to use it—a method still in vogue to-day—is extremely dangerous.

It appears that a tendency towards stuttering may be present in certain families; but, provided there is little emotional stress, the child may never stutter. In some children it would not affect their speech to change their handedness, whereas with those nearer the borderline of stuttering, the emotional stress might be sufficient to begin stuttering.

Certain periods appear to be critical with regard to speech development, and attempts to change handedness at these ages may have adverse effects on speech. It would seem desirable for the child to develop dominant handedness as early as possible, and anything which delays that is bad. Where children are late in speaking, it has been found that they have not developed dominant handedness. In such cases both Orton and Travis, two Americans who have studied the problem, advocate training handedness as an important factor in assisting speech development. Speech and handedness appear to be closely connected.

The educational implications of left-handedness are considerable, and statements have been made that left-handed children are inferior in all types of ability. It is certain that many difficulties confront the left-handed children, including the mechanics of writing. Lack of expert tuition, or even guidance of any kind, means that a left-handed child merely copies with the left hand the motions of the other children, many of which should be reversed.

The direction of motion, with reference to the body axis, involved in writing is an awkward one for the left-handed child. The motion for the right-handed child is away from the body, while it is in towards the body for the left-handed one. Without suggesting the motion, if a left-handed child is asked to rule a line he will almost invariably rule from right to left, revealing his natural directional movement.

A comfortable position for pencil or pen, in preparation for writing, is easy to acquire with the right hand; this is not so for the left unless one writes from right to left.

One has to be left-handed to realize the difficulties which face a sinistral in writing in ink—especially with a plain pen. The inkwell is on the wrong side of the desk and, when writing, a left-handed child has to draw his hand across what he has already written. The sharp-pointed nibs commonly used in schools are quite unsuitable for left-handed children, who push a pen where a right-handed child would pull, and are therefore inclined to make holes in the paper. Yet, although 4 per cent of the population is left-handed, little attempt is made to help them with writing.

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Evidence for the Pauling–Corey α-Helix in Synthetic Polypeptides

We have calculated, in collaboration with Dr. V. Vand[1], the Fourier transform (or continuous structure factor) of an atom repeated at regular intervals on an infinite helix. The properties of the transform are such that it will usually be possible to predict the general character of X-ray scattering by any structure based on a regular succession of similar groups of atoms arranged in a helical manner. In particular, the type of X-ray diffraction picture given by the synthetic polypeptide poly-γ-methyl-L-glutamate, which has been prepared in a highly crystalline form by Dr. C. H. Bamford and his colleagues in the Research Laboratories, Courtaulds, Ltd., Maidenhead, is so readily explained on this basis as to leave little doubt that the Pauling–Corey α-helix[2], or some close approximation to it, exists in this polypeptide. Pauling and Corey[3] have already shown this correspondence in the equatorial plane; it is shown here that the correspondence extends over the whole of the diffraction pattern.

We quote here the value of the transform which applies when the axial distance between successive turns of the helix is P, the axial distance between the successive atoms lying on the helix is p, and the structure so formed is repeated exactly in an axial distance c. (For the latter condition to be possible, P/p must be expressible as the ratio of whole numbers.) In this case, the transform is restricted to planes in reciprocal space which are perpendicular to the axis of the helix, and occur at heights $\zeta = l/c$, where l is an integer. In crystallographic nomenclature, these are the layer lines corresponding to a unit cell of length c. On the lth such plane the transform has the value:

$$F\left(R,\psi,\frac{l}{c}\right) = f \sum_n J_n(2\pi Rr) \exp\left[in\left(\psi + \frac{\pi}{2}\right)\right]. \quad (1)$$

(R,ψ,ζ) are the cylindrical co-ordinates of a point in reciprocal space, f is the atomic scattering factor, and J_n is the Bessel function of order n; r is the radius of the helix on which the set of atoms lies, the axes in real space being chosen so that one atom lies at $(r,0,0)$. For a given value of l, the sum in equation (1) is to be taken over all integer values of n which are solutions of the equation,

$$\frac{n}{P} + \frac{m}{p} = \frac{l}{c}, \quad (2)$$

m being any integer[1].

Thus only certain Bessel functions contribute to a particular layer line. This is illustrated in the accompanying table for the case of poly-γ-methyl-L-glutamate, for which Pauling and Corey[2] suggested $P = 5{\cdot}4$ A., $p = 1{\cdot}5$ A. and $c = 27$ A. The first column lists the number, l, of the layer line, while the second gives the orders (n) of the Bessel functions which contribute to it (for simplicity only the lowest two values of n are given for each layer line).

Now there is, of course, more than one set of atoms in the polypeptide, but for all of them, P, p and c are the same, although r is different. The basis of our prediction is that a reflexion will be absent if the contribution of all sets of atoms to it is very small, and that on the average it will be strong if all sets of atoms make a large contribution.

Value of l for the layer line	Lowest two values of n allowed by theory			Observed average strength of layer line (ref. 4)
0	**0**		± 18	strong
1	− 7		+ 11	
2	+ **4**		− 14	*weak
3	− **3**		+ 15	very weak
4	+ 8		− 10	
5	+ **1**		− 17	medium
6	− 6		+ 12	
7	+ 5		− 13	
8	− **2**		+ 16	weak
9		± 9		
10	+ **2**		− 16	weak
11	− 5		+ 13	
12	+ 6		− 12	
13	− **1**		+ 17	very weak
14	− 8		+ 10	
15	+ 3		− 15	
16	− 4		+ 14	
17	+ 7		− 11	
18	**0**		+ 18	medium
19	− 7		+ 11	
20	+ 4		− 14	
21	− 3		+ 15	
22	+ 8		− 10	
23	+ **1**		− 17	trace
24	− 6		+ 12	
25	+ 5		− 13	
26	− **2**		+ 16	trace
27		± 9		
28	+ **2**		− 16	trace

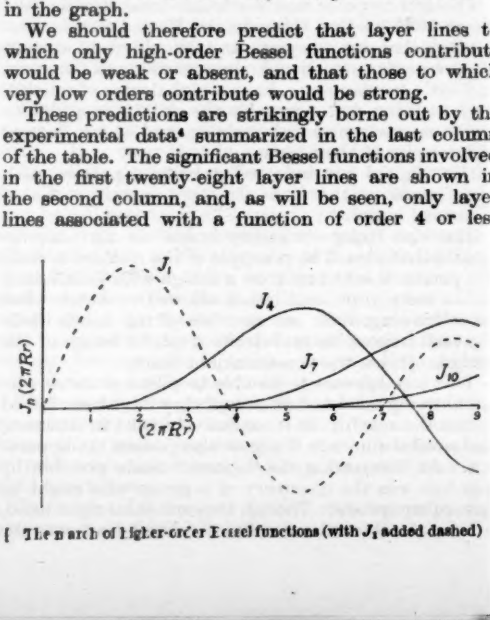
Layers not described are absent.

* $(10\bar{1}2)$, the reflexion having the smallest value of R, is absent.

It is a property of Bessel functions of higher order, illustrated in the graph, that they remain very small until a certain value of $2\pi Rr$ is reached, and that this point recedes from the origin as the order increases. Now, whatever the precise form of the chain, the value of r for any atom cannot be greater than about 8 A. because of the packing of the chains. This sets a limit to the value of $2\pi Rr$ within the part of the transform covered by the observed diffraction picture ($R < 0{\cdot}3$ A.$^{-1}$ for $l \neq 0$). No set of atoms can make an appreciable contribution to the amplitude of a reflexion occurring on a layer line with which only high-order Bessel functions are associated, because $2\pi Rr$ comes within the very low part of the curve in the graph.

We should therefore predict that layer lines to which only high-order Bessel functions contribute would be weak or absent, and that those to which very low orders contribute would be strong.

These predictions are strikingly borne out by the experimental data[4] summarized in the last column of the table. The significant Bessel functions involved in the first twenty-eight layer lines are shown in the second column, and, as will be seen, only layer lines associated with a function of order 4 or less



The march of higher-order Bessel functions (with J_1 added dashed)

are represented. This limiting value of 4 is less than might have been expected, and this fact suggests that the contribution of the side-chains to any reflexion is small, probably due to their large thermal motion.

In addition, the theory predicts (as can also be shown by a simpler approach) that meridional reflexions can occur only on layer lines which involve Bessel functions of order zero; that is, at reciprocal spacings of multiples of 1/1·5 A.$^{-1}$. This had previously been pointed out by Perutz[3] when reporting the strong meridional 1·5-A. reflexion.

We have therefore no doubt that the structure of poly-γ-methyl-L-glutamate is based on a helix of eighteen residues in five turns and 27 A., or a helix which approximates to this very closely. As the structure proposed by Pauling and Corey[2] satisfies these conditions and is also stereochemically very satisfactory, it seems to us highly probable that it is correct.

We should like to thank Dr. Bamford and his colleagues for allowing us to quote their experimental results in advance of publication, and Sir Lawrence Bragg and Dr. M. Perutz for the stimulus which their interest in this work has provided.

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Determination of the Atomic Mass of Phosphorus by a Nuclear Reaction Method

The Q-value of the reaction $^{31}P(d,n)^{32}S$ has been determined by the photographic plate method and used to calculate the mass of phosphorus-31. This reaction is suitable for the purpose, since an accurate redetermination of the mass of sulphur-32 (31·982218 ± 0·000025 m.u.) has been recently reported by Nier[1] using a double-focusing mass-spectrometer.

A thin (60-keV.) phosphorus target deposited on a thick gold backing was bombarded by deuterons of incident energy 8·13 ± 0·05 MeV. The neutrons emitted were detected by using photographic emulsion 600 μ thick. From measurements of the ranges and orientations of the recoil protons in plates exposed at two angles (0° and 40°) of emission, the energy spectra of the emitted neutrons were obtained. The Q-values calculated for the long-range neutron group at the two angles of observation agree well, and give Q = 6·81 ± 0·08 MeV. Using the mass of neutron and deuteron as given by Bainbridge[2], we found the mass of phosphorus-31 to be 30·98375 ± 0·00009 m.u., which agrees, within the experimental errors, with the value of 30·9843 ± 0·0005 m.u. obtained by Aston[3] from the mass-spectroscopic measurements of the mass difference of the CF—P doublet.

Further confirmation is obtained from the work of Peck[4] on the reaction $^{30}Si(d,n)^{31}P$ and that of Strait, Van Patter, Buechner and Sperduto[5] on the reaction $^{31}P(d,\alpha)^{29}Si$. The Q-values of these reactions are 4·56 ± 0·13 MeV. and 8·17 ± 0·02 MeV. respectively. Using the mass of silicon-29 and silicon-30 as reported by Duckworth, Preston and Woodcock[6], and the mass of the alpha-particle as given by Strait *et al.*[5], the mass of phosphorus-31 is found to be 30·98378 ± 0·00021 m.u. and 30·98359 ± 0·00014 m.u respectively. Both these values are in agreement with our result of 30 98375 ± 0·00009 m.u.

Also, from the present determination of the mass of phosphorus-31, the masses of phosphorus-30 and -32 have been calculated from the Q-values of the reactions $^{31}P(\gamma,n)^{30}P$ and $^{31}P(d,p)^{32}P$, as reported by McElhinney, Hanson, Becker, Duffield and Diven[7] and by Strait *et al.*[5] respectively. The mass of phosphorus-30 is found to be 29·98808 ± 0·00022 m.u. and that of phosphorus-32 is 31·98423 ± 0·00009 m.u.

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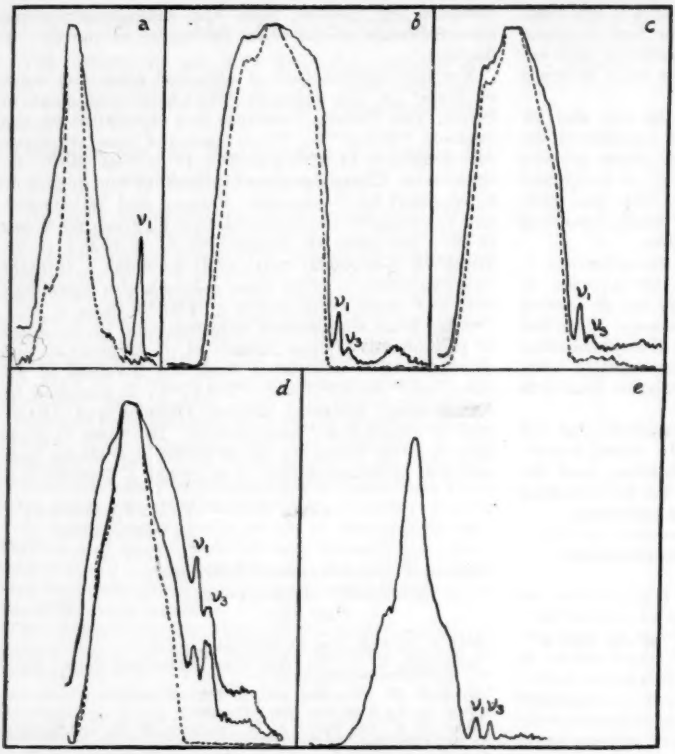
Configuration of the Uranyl Ion

X-ray crystallographic data[1,2] indicate that in solid uranyl salts and metallic uranates the UO_2^{++} ion is linear, and if this configuration is retained, only one frequency corresponding to the symmetric ν_1 vibration should appear in the Raman spectra of uranyl salt solutions. Actual observations[3–5], however, have shown at least two fundamental frequencies, at about 860 cm.$^{-1}$ and 200 cm.$^{-1}$, which have been assigned to the symmetric ν_1 and bending ν_2 vibrations respectively. Satyanarayana[4] found also a weak line at 909 cm.$^{-1}$, corresponding to the asymmetric ν_3 vibration. These results suggest that the UO_2^{++} ion in solution is bent, a conclusion supported by the infra-red spectral measurements, in which the ν_1 frequency, forbidden for a linear model, has always been observed. Both Crandall[5] and Satyanarayana have suggested that the ion might be linear in solution, local forces being responsible for the appearance of forbidden frequencies in the spectra. Hitherto, no experimental evidence has been put forward in support of this contention.

Assuming a linear ion, and taking the uranyl fluoride structure as a guide, the uranyl ion in solution is probably hexahydrated, the six water molecules forming a puckered ring around the equator of the ion as the F^- ions do in the UO_2F_2 crystal lattice[2]. The angle between the OH_2 and the UO_2 groups will be about 73°. A complexing anion



Raman spectra of: (*a*) saturated uranyl chloride (incident light, dotted line); (*b*) uranyl chloride saturated with hydrochloric acid, and of saturated hydrochloric acid (dotted line); (*c*) uranyl chloride saturated with calcium chloride, and of saturated calcium chloride (dotted line); (*d*) uranyl chloride saturated with UO_3 (incident light, dotted line); (*e*) saturated uranyl nitrate

replacing one of these water molecules, in addition to polarizing the two U = O bonds to different extents, will set up an asymmetric field which will cause changes in the polarizability of the UO_2^{++} ion during the bending and asymmetric vibrations, the former vibration being the more sensitive to the effect. The ν_2 and ν_3 frequencies should therefore be observed in the Raman spectrum, the bending frequency being the more intense and also doubly degenerate.

The chloride ion forms complexes with the uranyl ion[6,7], although not to such a great extent as does the nitrate ion[8], in which case, presumably, two of the nitrate oxygens occupy two adjacent sites around the UO_2^{++}. Hydrolysis of uranyl salts leads to the formation[9] of $U_2O_5^{++}$ and $U_3O_8^{++}$, which consist of UO_2^{++} ions with $O^=$ ions bridging the uranium atoms. The effect of the oxide ions on the linked UO_2^{++} ions should be the same as that of the Cl^- ion in the chloride complex, and since a saturated uranyl chloride solution will dissolve about 60 per cent excess UO_3, a solution can be prepared in which most of the ions ought to give three active Raman frequencies.

To test this hypothesis, Raman spectra were measured for (*a*) saturated uranyl chloride, (*b*) uranyl chloride saturated with hydrochloric acid, (*c*) uranyl chloride saturated with calcium chloride, (*d*) uranyl chloride saturated with UO_3, and (*e*) saturated uranyl nitrate. A single-prism quartz spectrograph was used with a conventional irradiation system. With the 5461 A. mercury line as exciting radiation, exposures of 2–8 hr. were necessary using Ilford Rapid Process Panchromatic or *H.P.*3 plates. Microphotometer tracings of the spectra are shown in the accompanying graphs.

Due to the low dispersion of the instrument, the ν_2 frequency was not resolved from the exciting line, although its presence is evident in all the spectra and its intensity is greater in cases (*b*) — (*e*) than in (*a*). The appearance of the ν_3 frequency with increasing intensity in the order (*b*), (*c*), (*e*), (*d*), that is, in the order of increasing concentration of complexed ions, is clearly observed. In general, the results agree with the concept of a linear ion disturbed by strong local fields.

Further investigations are being carried out on an instrument with higher dispersion in order to resolve ν_2 from the exciting line and to obtain more accurate frequency values. Solutions of uranyl nitrate in organic solvents, alone and in the presence of quaternary ammonium nitrates, are also being investigated. The trinitrato-uranyl ion[10] formed in the latter case should lead to a more symmetric field around the UO_2^{++} ion than is present in either the mononitrate or the dinitrate complexes, and the intensities of the forbidden frequencies ν_2 and ν_3 should therefore decrease. This work will be fully reported at a later date.

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Resonant Cavity Measurements on a D.C. Discharge

In the course of experiments carried out in this laboratory to determine the relative permittivity, K_1, of an ionized gas in the microwave band, an interesting phenomenon was observed.

A low-pressure D.C. discharge tube, with a mercury pool as cathode[1], is placed axially in a cylindrical cavity of circular cross-section which resonates in

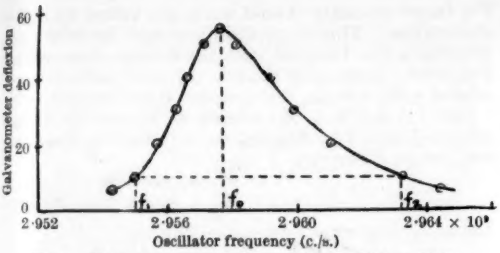

Fig. 1. Resonance curve for I_a = 300 mA. and T = 22° C.

the H_{011} mode. By measuring the increase in the resonant frequency of the cavity caused by known current I_a, in the discharge tube, it is possible to deduce the value of K_1 for that value of I_a. It has been noticed that for certain values of discharge current and mercury pool temperature T, the resonance curves are quite asymmetrical. A typical example is shown in Fig. 1, for which I_a = 300 m.amp. and T = 22° C.

It has been found that this asymmetry is caused by fluctuations in the discharge, which make the cavity swing in and out of resonance for fixed oscillator frequencies on either side of the apparent resonant frequency, f_0, as shown in Fig. 1.

Fig. 2 shows oscillograms of the voltage developed across the crystal load at frequencies f_1 ($< f_0$) and f_2 ($> f_0$). At f_1 the cavity is more nearly resonant when some fluctuation in the discharge decreases the effect that the discharge has on the tuning of the cavity, whereas at f_2 a fluctuation which increases the effect of the discharge is required.

It is clear from Figs. 1 and 2 that the increases in the resonant frequency of the cavity above f_0 are greater in magnitude than the corresponding decreases below f_0. In fact, at f_2 the fluctuations are so large that the cavity is brought through resonance and even detuned slightly until the fluctuation dies away and the cavity goes through resonance again. This is shown by the double-humped pulse in the crystal current. The galvanometer records the average of the crystal current pulses, and since above f_0 the pulses are much greater in magnitude than those below, it follows that the resonance curve as given by the galvanometer will be asymmetrical as in Fig. 1.

It seems that there are two mechanisms which might create the necessary fluctuations in the discharge. The first is that the current may fluctuate irregularly in such a way that the positive fluctuations are greater in magnitude than the negative fluctuations. The second is that the radial distribution of electron density may fluctuate, and it can be shown that the increase in the resonant frequency

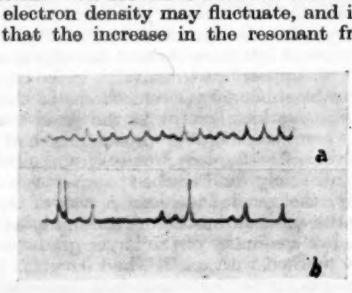

Fig. 2. Oscillograms of crystal current. Oscillator frequency in (*a*) is f_1 ($< f_0$), in (*b*) is f_2 ($> f_0$). Time sweep = 1·5 m.sec.

caused by a positive radial displacement of a given charge concentration is greater than the corresponding decrease for an equal negative displacement.

Experiments are being carried out to discover which of the two mechanisms is the more important, and the results of these experiments will be published later.

We wish to thank Prof. H. E. M. Barlow for his interest in this work and for the provision of laboratory facilities, and one of us (K. W. H. F.) is indebted to the Department of Scientific and Industrial Research for a grant enabling him to carry out the experimental research.

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Plastic Deformation and the Meyer Constants of Metals

The Meyer hardness (H_m) of a metal is defined as the ratio of the load on a spherical indenter (radius r) to the projected contact area of the resulting indentation (diameter, $2a$). The relation between the diameter of the indentation and the corresponding Meyer hardness is given by the following empirical expression[1,2]:

$$H_m = H_u\,(a/r)^{n-2}. \qquad (1)$$

The constant H_u is called the ultimate Meyer hardness. Experimentally, both H_u and n are independent of the radius of the indenter. For cubic metals, n decreases (from 2·5 to 2·0), whereas H_u increases, with increasing amounts of cold work. Recent experimental work by Finniston, Jones and Madsen[3] seems to suggest that, for non-cubic metals, both H_u and n increase with cold work.

It can be shown that if the true stress-strain curve of annealed metals can be represented by:

$$\sigma = g\varepsilon^x, \qquad (2)$$

where x (for annealed cubic metals[4] about 0·5) and g are constants of the metal, σ the true stress and ε the plastic elongation, then H_u must increase and n must decrease with increasing amounts of cold work.

Tabor[5] has shown that if the true stress-strain curve of annealed metals can be represented by (2), then H_m can be written:

$$H_m = cg\,(0{\cdot}20\,a/r)^x, \qquad (3)$$

where c is a constant. If the metal has been cold-worked by an amount ε_0, it may be considered as an unworked metal that has undergone a total plastic deformation equal to the sum of the initial deformation ε_0 and any subsequent deformation ε, provided no recovery has taken place. In view of this, (2) can be written as $\sigma = g(\varepsilon_0 + \varepsilon)^x$. Similarly, Tabor has extended (3) to the case of worked metals:

$$H_m = cg\,(\varepsilon_0 + 0{\cdot}20\,a/r)^x. \qquad (4)$$

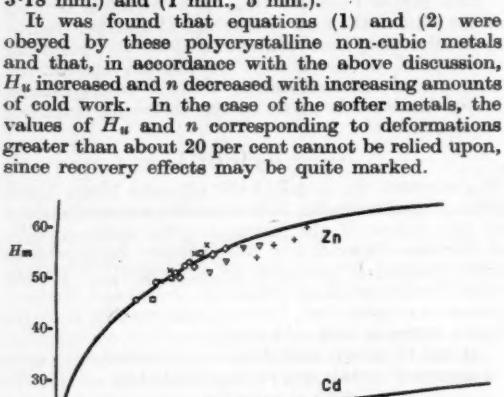
Should the initial plastic deformation be disregarded, equation (4) becomes approximately an equation of the form (3). Therefore:

$$H_m = cg\,(\varepsilon_0 + 0{\cdot}20\,a/r)^x \approx cg\,(\varepsilon_0)\,(0{\cdot}20\,a/r)^{x(\varepsilon_0)}, \qquad (5)$$

where $g(\varepsilon_0)$ and $x(\varepsilon_0)$ are functions of the initial plastic deformation. Equation (5) is equivalent to equation (1). As is easily seen from the form of the stress-strain curve, $g(\varepsilon_0)$ will be an increasing and $x(\varepsilon_0)$ a decreasing function of ε_0. If, therefore, the stress-strain curve of a metal can be approximated by an equation of form (2) and the Meyer constants evaluated from the experimental results from (5) or (1), then n must always decrease and H_u must always increase with increasing amounts of cold work. This conclusion is a necessary feature of the property exhibited by annealed metals, namely, an initial rapid rate of work-hardening followed by a decreasing rate. The above conclusion is confirmed by experiments for cubic metals, but is not in accordance with the work of Finniston, Jones and Madsen on non-cubic metals.

Experiments were carried out on well-annealed samples of tin, zinc and cadmium. Impressions were made immediately after (to minimize recovery effects) a specimen had been rolled to the required percentage. All these metals exhibited a definite continuous flow after the load had been applied. The time of loading and the ball diameters for tin, zinc and cadmium were, respectively: (2 min., 10 mm.), (2 min., 3·18 mm.) and (1 min., 5 mm.).

It was found that equations (1) and (2) were obeyed by these polycrystalline non-cubic metals and that, in accordance with the above discussion, H_u increased and n decreased with increasing amounts of cold work. In the case of the softer metals, the values of H_u and n corresponding to deformations greater than about 20 per cent cannot be relied upon, since recovery effects may be quite marked.



Meyer hardness plotted as a function of $\varepsilon_0 + 0{\cdot}20\ a/r$. The curves were calculated from equation (6)

By consideration of equation (4), it is possible to correlate the different hardness numbers, corresponding to different loads and plastic deformation, when no recovery has taken place. If H_m is plotted as a function of $\varepsilon_0 + 0{\cdot}20\ a/r$, the hardness numbers corresponding to different loads (different a's) and degrees of cold work should all lie on the same curve. As is seen from the accompanying graph for moderate amounts of plastic deformation (less than 20 per cent), the points lie on a curve, which can be represented, using the experimental values of H_u and $n - 2$ for $\varepsilon_0 = 0$, by:

$$\begin{aligned} &\text{Zn}: \ H_m = 24\,(\varepsilon_0 + 0{\cdot}20\ a/r)^{0{\cdot}21}/(0{\cdot}20)^{0{\cdot}21} \\ &\text{Cd}: \ H_m = 13\,(\varepsilon_0 + 0{\cdot}20\ a/r)^{0{\cdot}22}/(0{\cdot}20)^{0{\cdot}22} \qquad (6) \\ &\text{Sn}: \ H_m = 60\,(\varepsilon_0 + 0{\cdot}20\ a/r)^{0{\cdot}25}/(0{\cdot}20)^{0{\cdot}25}. \end{aligned}$$

For larger amounts of cold work, the values lie below the curves. This is probably caused by recovery. It is therefore believed that the effects observed by Finniston, Jones and Madsen are not characteristic of non-cubic metals, but possibly due to recovery.

One of us (M. A. M.) wishes to thank the South African Council for Scientific and Industrial Research for financial support.

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Grain Movements during Creep

During an investigation of the creep properties of a range of solid-solution alloys of thallium in lead, an interesting observation concerning their mode of deformation has been made. This concerns several alloys containing about 5 atoms per cent of thallium, which were tested in the form of extruded strip, directly loaded. Under conditions of slow straining, the specimens extended by large amounts before breaking.

The most striking example was that of a specimen of an alloy containing 8 atoms per cent thallium, which was loaded at 300 lb./in.[2] initially and which extended 372 per cent in 221 days; the fracture, which was of a ductile knife-edge type, occurred away from the grips and the specimen tapered almost uniformly from the grips to the point of fracture. There was a minimum creep-rate of about 37×10^{-2} per day until a prolonged tertiary stage set in at 50 days; the creep curve was of the same general shape as that shown for another alloy loaded at 500 lb./in.[2] which was published previously[1].

X-ray back-reflexion photographs, after a gradual broadening of the spots with increasing strain, showed no new sharp reflexions, and the absence of the characteristic 'humps', associated with recrystallization during creep on the creep curve, confirms that no obvious recrystallization took place. No cracks were observed, and little, if any, preferred orientation was produced.

The specimen was polished before testing, and a slight strain (of less than 1 per cent) revealed the grain boundaries clearly, as shown in Fig. 1, at a magnification of 100 diameters. A few slip lines were observed to appear progressively with increasing strain; but at about 50 per cent extension there was little surface marking except in the grain-boundary regions, where considerable broadening had taken place. Even after fracture, many grains could still be seen relatively undisturbed; after repolishing chemically, the general impression was of equiaxed grains of the same size as before straining, as shown in Fig. 2, but a number of the larger grains, some of which are marked with an 'X', had irregular boundaries and peninsula-like extensions between other grains. The axis of tension was parallel to the long edge of the photomicrographs. Similar effects have

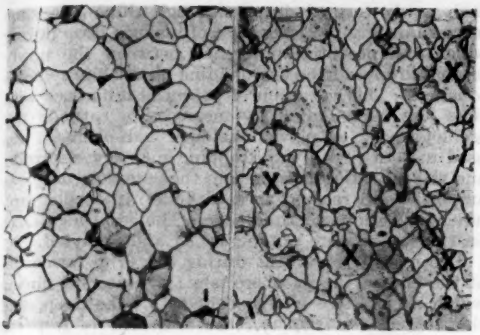

Fig. 1. Lead–thallium alloy after slight strain to reveal grain boundaries. × 100
Fig. 2. Same specimen as Fig. 1, repolished after 372 per cent extension in 221 days. × 100

been observed in other specimens of this and certain other lead–thallium alloys.

Thus there has been no obvious recrystallization, and since most of the grains have not extended appreciably during deformation, slip—or any other process which results in the extension of individual grains to conform to that of the aggregate—does not appear to have been predominant in bringing about the extension of the specimen. It seems therefore, on the present evidence, that deformation has taken place to a great extent by the relative movement of grains, and the appearance of the elongated grains (marked in Fig. 2) suggests that some of the movement at least has resulted from a process of one grain squeezing between, or being squeezed by, its neighbours. The detailed mechanism of such a process is difficult to imagine, and further work is being devoted to confirming and extending the above observations.

The work described has been carried out as part of the programme of research of the Physical Metallurgy Section of the Commonwealth Scientific and Industrial Research Organization.

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An Improved Method for the Measurement of the Velocity Profiles in Liquids

Birchoff and Cagwood[1] have described a method for the measurement of velocity distributions in liquids using a sheet of equally spaced rising air bubbles. These are photographed against a dark background, with flash-tube illumination, using the light scattered from the air bubbles; two exposures are recorded on the same plate from two flashes at a known interval apart. Relf[2] has used oil drops dispersed in water, illuminated by an arc lamp, to measure fluid velocity. The drops appear as bright points, and thus a time exposure enables the fluid velocity to be found.

We have modified and extended these methods to study the velocity profile of a fluid flowing in a pipe of circular section. A few hundred drops (approximately 0·15 mm. diameter) are produced in water, contained in a reservoir which supplies a circular pipe, by forcing a mixture of benzene and carbon tetrachloride through a fine metal capillary tube (internal diameter, 0·015 cm.). The proportions are adjusted so that the drops have the same density as water. As the water moves through the pipe they are illuminated by light from a flash-tube (Siemens *S.F.* 6) which is rendered parallel by a cylindrical lens. The light-beam enters a box shown in section in Fig. 1 at an angle of 25° to the plane of the paper. The drops appear as bright points when viewed by the scattered light. We have, in fact, split the incident beam by a mirror system (not shown in Fig. 1) to produce two beams which enter the box in two directions at right angles as indicated by the arrows in Fig. 1. This introduces an element of symmetry which ensures that the centre of the drop corresponds with the centre of the bright spot. The surface-aluminized mirrors M_2 and M_3, together with the semi-silvered mirror M_1, enable the exact position of the drop in the pipe to be obtained. Light scattered in the direction DA, reflected at A and B, gives rise to an image D_1, and similarly light scattered in the direction DA' gives rise to an image D_2. The distance of these images from the centre of the pipe gives the x- and y-co-ordinates of the drop D. These images are recorded on the ciné camera at R. The centre of the pipe is determined by photographing the edges of the pipe on each frame with auxiliary illumination (not shown in Fig. 1). A second photograph is obtained on the same frame from a second flash-tube at a known time interval later; the time interval is determined electronically. Thus each drop gives rise to four images from which, by measurement with a travelling microscope, the position and velocity of the drop can be found.

The box is square in section and made from 'Perspex' strip held in milled slots in flat brass end-pieces. The space between the box and the tube is filled with water to minimize glare and distortions, though corrections are applied for refraction through the glass of the pipe. A continuous record is obtained by repeating the double flash at regular intervals, but details of the double-flash stroboscope with its associated electronic equipment will be published elsewhere.

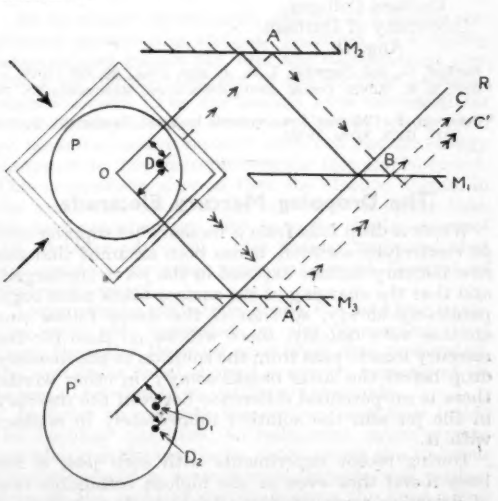

Fig. 1

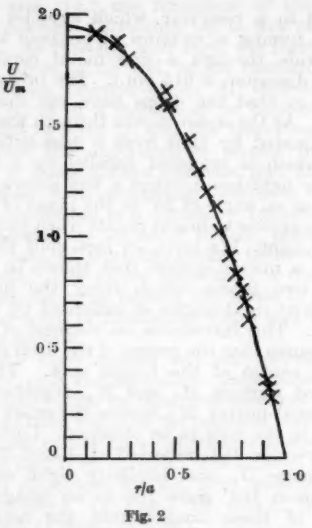

Fig. 2

As an illustration of the method, Fig. 2 shows the velocity distribution calculated from the experimental observations, recorded at a point 83 diameters from the entry, for the flow of water through a circular pipe at a Reynolds number of 2,200. The flow is laminar at this high Reynolds number due to a flared entry into the pipe from the reservoir. The full line is the calculated velocity distribution after Schiller and Nikuradse taken from Goldstein[3]. These results are taken from several frames, and some of the scatter is due to interference of the drops with each other and to the uncertainty of repeating the exact time interval in successive double flashes.

We are grateful to Prof. J. E. P. Wagstaff for the facilities he has placed at our disposal, and one of us (R. M. U.) to the Council of the Durham Colleges for a research grant.

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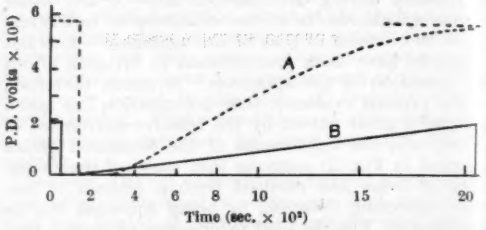
The Dropping Mercury Electrode

When a drop falls from a mercury jet dipping into an electrolytic solution, it has been assumed that the new mercury surface exposed in the jet is uncharged, and that the charging of the surface takes place comparatively slowly, so that if the drops follow one another very quickly, there will be no time for the mercury ions to pass from the solution to the mercury drop before the latter breaks away; in other words, there is no potential difference between the mercury in the jet and the solution immediately in contact with it.

During recent experiments with such jets, it has been found that even at the highest attainable rate of dropping some positive charge is deposited upon each newly formed drop, although there is a time interval during the formation of a single drop during which the potential difference between the newly formed drop and the surrounding electrolyte remains constant. This variation of potential difference with time was investigated by means of a cathode ray oscillograph. A normal calomel half-element was used in series with the dropping mercury electrode, and the potential difference in the complete unit was amplified and relayed to a cathode ray oscillograph having a calibrated time base. The resulting traces on the screen were photographed and analysed.

The results show that during the drop formation at the end of the jet there is a time interval during which no positive charge collects on the drop, and that this time interval decreases as the rate of dropping increases. Thus with a drop formation of 2 sec. no charge on the drop was detected for 0·014 sec., whereas with a formation time of 0·2 sec. this time interval was 0·007 sec. These results are shown in the accompanying graph, where curve *A* represents the variation of potential difference with time during the formation of the 2-sec. drop and curve *B* that for the 0·2-sec. drop.



The variation in the time-interval during which the potential difference remains constant can be explained by diffusion of the mercury ions in solution towards the jet. The positive charge on the surface of the drop increases, and the concentration of mercury ions in the immediate neighbourhood of the surface decreases. Thus when another drop is formed, there is a time lag between the commencement of formation and deposition of mercury ions upon the surface, and this time lag depends upon the concentration of mercury ions near the surface, that is, upon the rate of dropping. A higher rate of dropping will produce a smaller change in the concentration of mercury ions.

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Action Potentials in the Cerebral Cortex

Monophasic action potentials of little more than 1 m.sec. duration and of up to 35 mV. amplitude have been recorded from the cerebral cortex of the cat and the rabbit. The steel micro-electrodes used were reduced electrolytically[1,2] to a shaft diameter of about 100 μ, copper plated, and insulated with varnish to the tip, which was platinized and of less than 5 μ diameter. Such electrodes of about 5 mm. length were mounted to project 0·5–2·0 mm. from small 'Perspex' squares, and flexibly connected to a high-impedance input stage and D.C. amplifier[3].

As well as occurring spontaneously, these action potentials have been found in the primary visual

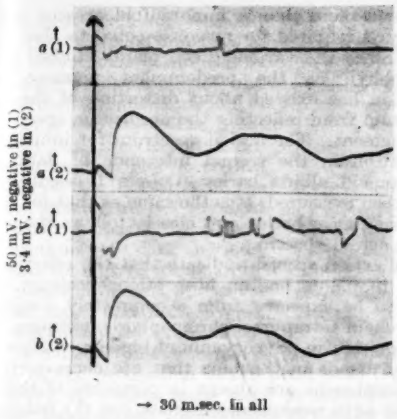

Fig. 1. (*a*) and (*b*) are records of the potential changes in the visual cortex of a cat under nembutal, resulting from electrical stimulation (marked by the arrow) of the contralateral retina. Records (1) are from a micro-electrode and show bursts of brief action potentials in response to stimulation. Records (2) are from large silver ball electrodes on the surface of the pia. The latter are reproducible, but the former are not, partly owing to displacements of the micro-electrode by the movements of the cortex accompanying respiration. In all records the indifferent electrode was a platinized platinum wire in Ringer-agar on the surface of the parietal cortex

cortex in response to electrical stimulation of the contralateral retina, when they sometimes occur in high-frequency bursts. Both negative and positive potentials have been observed, though the former greatly predominate. When slightly larger or poorly insulated micro-electrodes are used, the increased capacity to inactive tissue is sufficient to integrate the bursts of monopolar action potentials into brief waves, and intermediate stages of integration are also found. This constitutes evidence that the waves normally recorded with larger electrodes can be built up by the integration of bursts of brief potentials, in confirmation of the hypothesis of Adrian and Matthews[4].

Monophasic action potentials of about the same duration but of less than 500 μV. amplitude have

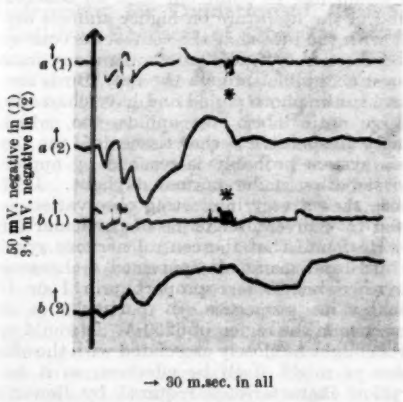

Fig. 2. The labels are as in Fig. 1, except that in this case the records (2) were taken from a large micro-electrode 100 μ above the first and show the integration of these and other action potentials into brief waves. The bursts of potentials marked with stars are seen to reverse their polarity from positive to negative in successive stimulations, probably owing to a small displacement of the micro-electrode

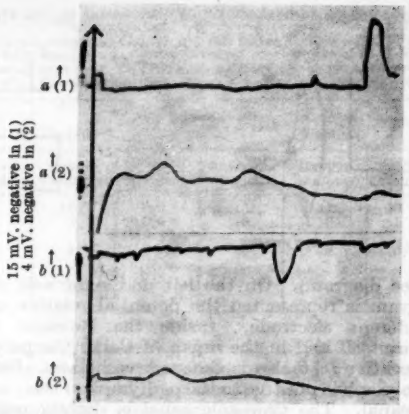

Fig. 3. The labels are as before, except that these records were obtained from a rabbit under nembutal. Records (1) show single brief action potentials on a faster time-base, and records (2) from large surface electrodes show the beginning of the gross response of the cortex

previously been recorded spontaneously from the surface of the cerebral cortex of rabbits[5], and with wire electrodes from the cerebellar cortex, spontaneously and in response to stimulation[6].

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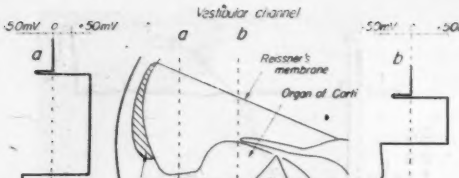
Resting Potentials Inside the Cochlear Partition of the Guinea Pig

In an earlier experiment[1], the tip of a needle was pressed against the cochlear partition of a lightly anæsthetized guinea pig, and the microphonics produced by the displacement of the cochlear partition were observed. The mechanical work necessary for a certain displacement of the cochlear partition could be measured and compared with the electric energy produced by the microphonics for this displacement. This comparison showed that the electric output in the vestibular canal of the cochlea was larger than the mechanical energy used up in the displacement of the cochlear partition. This finding suggested that the cochlear partition contains a pool (source) of electrical energy.

Large resting potentials inside the cochlear partition were also suggested by the observation that every time the Reissner membrane was perforated, the vestibular canal showed a sudden increase of its potential relative to an indifferent electrode.

In order to measure the resting potentials inside the cochlear partition, an indifferent micro-pipette was placed in the vestibular canal above the Reissner membrane and a second micro-pipette was pushed through the cochlear partition along the lines *a* and



b (see diagram). On the left and right side of the diagram is represented the potential relative to the indifferent electrode. Inside the Reissner membrane itself and in the organ of Corti, the potential is negative; so also is the stria vascularis. But the endolymph is positive to the perilymph of the vestibular canal. The tympanic canal is slightly negative with respect to the vestibular canal.

Between the endolymph and the organ of Corti there is, near the helicotrema, a potential jump of about 100 millivolts. But close to the round window the equivalent movement of the electrode shows between the organ of Corti and the endolymph a potential jump of about 130 millivolts.

To avoid junction potentials, the micro-pipettes were filled with a concentrated solution of potassium chloride.

Further investigation will be required to show to what degree these resting potentials contribute to the production of the aural microphonics and the other potentials produced in the inner ear by stimulation.

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Photoperiodic Responses of Plants and Animals

Interruption of the dark period of a 24-hr. cycle with visible radiation has been found to control reproduction in representatives of the Spermatophyta, Chordata, Arthropoda and Mollusca. Elongation, possibly cell division, in certain seedling structures is controlled by the same photoreaction as that for the photoperiodic control of reproduction in plants. It seems quite probable that the plumage cycles of birds, production of wings by aphids, prevention of diapause in some insects and the regulation of hair cycles of certain animals are controlled by the same photoreaction that controls sexual reproduction. A considerable volume of descriptive literature has grown up on this day-length phenomenon, which is a major expression of species adaptation to changing season.

The action spectra have been measured for flowering in *Glycine max* var. Biloxi and *Xanthium saccharatum*, two short-day plants, and in *Hordeum vulgare* var. Wintex and *Hyoscyamus niger* (annual), two long-day plants, as well as for promotion of leaf elongation in dark-grown seedlings of *Pisum sativum* and inhibition of elongation of the second internode in barley seedlings[1]. Each spectrum is of the same type, with maximum effectiveness in the red near 6200–6600 A., decreasing to a minimum near 4600 A., at which more than a hundredfold greater incident energy is required for response equal to that in the red. Since the various green plants studied carried chlorophyll as the predominant pigment, some question has existed about distortion of the action spectrum from reflecting the absorption spectrum of the pigment. The action spectrum for inhibition of elongation in the second internode of dark-grown acarotenoid albino barley (Colsess I) seedlings has now been measured. It is the same as that for control of flowering in barley and closely follows the several other action spectra.

The action spectra indicate that the effective pigment in plants has an absorption spectrum of the type to be expected from a completely conjugated open-chain tetrapyrrol chromophoric grouping of the type present in phycocyanin of blue-green algæ. The Verdet bands in the blue that are characteristic of the porphyrins are absent in pigments of this type as well as in verdohæmochromes, but the red absorption is retained. The chromophoric grouping could be of the biliverdin, pterobilin, or related classes. Pterobilin is of particular interest as a prominent pigment of the photoperiodically sensitive cabbage butterfly, *Pieris brassicæ*. Attempts to observe the pigment by light absorption in the albino tissue of barley infiltrated with glycerine have been unsuccessful, but indicate that the total absorption of incident radiation by the effective pigment of a leaf, the organ of perception, in the region of maximum effectiveness, is less than 0·001 per cent. In the sense of isolation the pigment is still to be discovered.

The limited observations on causation of photoperiodic responses of birds and mammals indicate that the region of perception is in the neighbourhood of the eye and that red incident radiation is far more effective than blue[2]. Benoit and Ott[3], working with Pekin ducks from which the eyes had been extirpated, found that, in radiation directed through the ocular cavity towards the region of the pituitary, blue was equal to or more effective than red. They emphasized that in birds and mammals on which the experimental work has been performed, absorption of radiation by blood and scattering by bone and tissue were very important. The sexual responses are, of course, mediated by the pituitary.

We would like to point out that all observations reported in the literature on higher animals are consistent with the idea that the central nervous system may be the tissue of perception. In many instances it is most accessible through the eye. Birds are very sensitive to the photo-period and have characteristically large optic lobes. In aphids, too, which are strikingly responsive[3], the tissue of the central nervous system probably is reached by appreciable visible radiation under normal daylight. If this is the case, then a very interesting observation, earlier reported by Klüver[4], might be of particular importance. He found that the central nervous system of most birds and mammals contained a characteristic porphyrin, which was coproporphyrin I or III as shown by its properties, in particular a strong fluorescence in the region of 6250 A. It would appear that this might be closely associated with the effective pigment or might itself be effective, as it has the absorption characteristics required by Benoit's observations. It is a very active photodynamic agent for sensitized oxidations, which is suggestive of melanism.

In working on animals, the almost exclusive tendency has been to consider the length of the light

period as determining reproduction. This might be described as a prejudice, partially induced by the term 'photoperiodism' and due further to identification of light with activity. The great majority of the experimental work on animals has no critical bearing on the question of the relative effectiveness of the light and dark periods. In plants, interruptions of dark periods, adequate for a given response, by short intervals of light, and use of unusual light and dark cycles, have shown that the length of the dark period controls the response. Very recent experiments on egg production in the pond snail (*Lymnæa palustris*[4]), as well as some work on reproduction in ferrets[5], have shown that control is readily effected by interruption by light near the middle of an adequate dark period. Here too then, as in plants, and as is photochemically reasonable, the effective measurement of time is afforded by slow dark reactions.

So far as we know, the nature of the initial reactions to light involved in these responses is unknown for both plants and animals.

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Diphosphopyridine Nucleotide and Phosphate Requirement for Oxidation of Amino-Acids by Cell-free Extracts of Obligate Anaerobes

Previous studies have shown that resting cells of *Clostridia* (*Cl. sporogenes GO*1, and *Cl. saccharobutyricum GR*4) may bring about the oxidative deamination of certain amino-acids in the presence of oxygen as hydrogen acceptor[1,2]. In order to study in greater detail the mechanism of the L-amino-acid oxidation, cell-free extracts of these bacteria were prepared by using ultrasonic vibration, at 960 kc./s., 11·3 W./cm.², in presence of a large excess of catalase.

The activity of the L-amino-acid oxidases was measured either as oxygen uptake and amount of ammonia liberated at the end of the experiment in Warburg flasks, or by the rate of reduction of methylene blue in narrow open tubes. In the presence of L-alanine as substrate, the oxidative activity of the crude extracts appeared to be independent of the nature of the buffer employed at *p*H 8. However, thoroughly dialysed extracts did show low activity in veronal, as compared with phosphate, buffer, and this difference in activity was emphasized as the dialysis became more prolonged and exhaustive. Addition of phosphate reversed this apparent 'inactivation', indicating that the oxidative reaction requires inorganic phosphate (see table). Phosphate could be replaced by arsenate, which on a molar basis appeared even more potent.

Effect of Inorganic Phosphate and of Diphosphopyridine Nucleotide on the Oxidation of L-Alanine

Each Warburg flask contains 0·8 ml. substrate (*M*/20), 0·1 ml. methylene blue (*M*/500), 1 ml. buffer (*p*H 8, *M*/5). In the side bulb was 0·5 ml. extract (45 mgm. dry weight) of *Cl. sporogenes*. Enzyme and substrate were mixed at zero time. In the centre well, 0·2 ml. 20 per cent potassium hydroxide. Total volume, 3·2 ml. Experimental time, 120 min.; $T = 37°$; gaseous phase, air

Extract	Buffer: Veronal			Buffer: Phosphate		
	Ammonia (μ mol.)	Oxygen (μ atoms)	Oxygen Ammonia	Ammonia (μ mol.)	Oxygen (μ atoms)	Oxygen Ammonia
Non-dialysed	16	16	0·5	15	17	0·56
Dialysed 225 min.	4	4	0·5	9	18	1
Dialysed + DPN (*M*/7,500)	4	4·5	0·56	20	30	0·75
Dialysed + arsenate (*M*/60) + DPN (*M*/7,500)	13	21	0·8			

With these dialysed extracts it could also be shown that the activity of the L-amino-acid dehydrogenases depends on the presence of coenzyme I in the reaction system (see table). Thus thoroughly dialysed extracts are inactive without addition of both phosphate and diphosphopyridine nucleotide. Its intervention in this reaction could be directly demonstrated by observing the reduction of added diphosphopyridine nucleotide at wave-length 340 mμ in the Beckman spectrophotometer. As may be seen from Fig. 1, the reduction of diphosphopyridine nucleotide requires the presence of phosphate or arsenate. Coenzyme II (triphosphopyridine nucleotide) in concentrations equivalent to those used for diphosphopyridine nucleotide had no activating effect; consequently the system appears to be specifically linked with the latter.

The reaction can be made to proceed in the opposite direction by addition of the corresponding α-keto-acid and ammonia to reduced diphosphopyridine nucleotide. Under these conditions, reduced diphosphopyridine nucleotide is rapidly re-oxidized (Fig. 2).

The pyruvic acid formed by the oxidation of alanine is further metabolized by a phosphoroclastic reaction. The enzyme which catalyses the latter reaction is present in most of our extracts[3]. This explains why

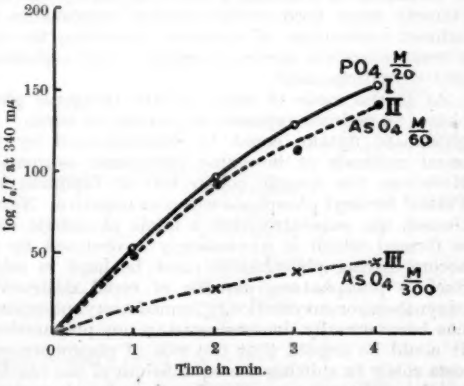

Fig. 1. Curve I, reduction of diphosphopyridine nucleotide (*M*/7,500) by alanine (*M*/200) in presence of 0·2 ml. extract of *Cl. sporogenes* (15 mgm.) and of phosphate (*M*/20, *p*H 8). Total volume, 3 ml.
Curve II, same as above, *M*/60 arsenate replacing phosphate.
Curve III, same as II, but *M*/300 arsenate

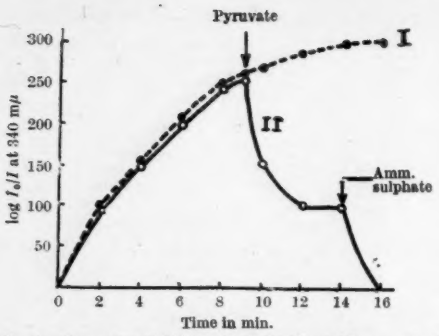

Fig. 2. Curve I, reduction of diphosphopyridine nucleotide (*M*/7,500) by 0·2 ml. (15 mgm.) extract of *Cl. sporogenes* (dialysed 240 min.) in presence of 0·3 ml. alanine (*M*/20), 1 ml. phosphate buffer (*M*/5, *p*H 7). Total volume, 3 ml.
Curve II, re-oxidation of reduced diphosphopyridine nucleotide by pyruvate and ammonia. Pyruvate 0·3 ml. (*M*/10) and ammonium sulphate added at arrows

the ratio oxygen/ammonia is generally greater than 0·5. The system mediating the transport of hydrogen from the reduced diphosphopyridine nucleotide to the final acceptor is the limiting factor of the reaction. The reaction ceases after a certain equilibrium between the reduced and oxidized forms of diphosphopyridine nucleotide is reached. Under these conditions, amounts of ammonia which are readily measurable are only formed in the presence of a suitable hydrogen acceptor such as potassium ferricyanide, which is capable of constantly re-oxidizing the reduced diphosphopyridine nucleotide.

Only amino-acids of the L-series are attacked by the bacterial extracts. In addition to L-alanine, the following other acids are oxidized by these extracts: *nor*leucine, leucine, *iso*-leucine and valine; the rate at which these substrates are oxidized decreases in the order named. The behaviour of all these is strictly analogous to that of L-alanine.

Parenthetically, it may be mentioned that a potent L-glutamic acid dehydrogenase was also found in our extracts. The latter system exhibits certain distinctive features, the details of which will be dealt with elsewhere. However, it may be pointed out here that addition of either L-glutamic acid or keto-glutarate in catalytic amounts was without effect on the rate of oxidation of L-alanine even when highly dialysed extracts were used. This makes improbable an indirect mechanism of oxidation operating through a transamination system coupled to the L-glutamic acid dehydrogenase[4].

As to the mode of action of the inorganic phosphate, no definite explanation can yet be given. No phosphate uptake could be demonstrated by the usual methods of inorganic phosphate estimation. Moreover, the specific colour test of Lipmann and Tuttle[5] for acyl phosphate was also negative. Nevertheless, the possibility that a labile phosphate ester is formed which is immediately hydrolysed by an accompanying phosphatase must be kept in mind. Such a phosphatase, capable of rapid destruction of synthetic or enzymatically formed acetyl phosphate, has been actually demonstrated in our preparations. It could be argued that the role of phosphate consists solely in shifting the equilibrium of the reaction to the right, since it enables the phosphoroclastic dissimilation of the keto-acids produced by the dehydrogenation of the L-amino-acids. Such an assumption seems unlikely in view of the following facts: monoiodoacetate, which at *M*/300 inhibits completely the oxidation of pyruvic acid, has only a slight depressive effect on the L-alanine oxidase; and some of our extracts did not contain any active keto-acid dehydrogenase although they retained their activity towards the amino-acids. Further work using acceptor systems for trapping labile phosphate bonds would be desirable.

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Toxins of the Egyptian Cobra (*Naja tripudians*)

Observations have been made on absorption spectra of natural venom and crystallized toxin (*Naja tripudians*)[1].

Fresh natural venom was milky in appearance, was soluble in 0·9 per cent saline and clotted on standing. Data on the absorption spectra are recorded in the accompanying table, from which it is seen that the crystalline toxin shows an absorption band at 278 mμ. The venom showed a band at 262·5 mμ, the shift to 278 mμ apparently occurring during the process of purification.

Absorption Spectra of Cobra Venom and Toxin

Substance	Cell (mm.)	$\lambda_{max.}$ (mμ)	$E_{max.}$	$\lambda_{min.}$	$E_{min.}$	M.L.D. (100-gm. rat)
Toxin (hydrochloric acid, 0·2 per cent)	5	278	1·16	253	0·67	0·03 mgm.
Venom (0·5 ml. + 1·5 ml. saline)	5	262·5	0·6	219	0·2	0·1 ml.

The toxin was stable when kept in solution in 0·1 *N* hydrochloric acid at 0° for at least six days, neither the absorption band nor the M.L.D. altering during this time. It was unstable in 0·1 *N* sodium hydroxide, the M.L.D. being at least ten times greater after 24 hr. at 0° C. and the characteristic absorption band becoming inflected. Toxin in distilled water at 55° C. was unaltered in 24 hr.; but after six days had only one-tenth its former activity and the absorption band had changed.

Solutions (0·2 per cent) of toxin in water with different concentrations of formalin were allowed to stand at 0° C. and examined at intervals for toxicity and for changes in the absorption spectra. With 0·5 per cent formalin toxicity decreased from M.L.D. 0·03 to 0·10 mgm. in fifteen days; with 1·0 per cent formalin the respective values were 0·03 and 0·15 mgm. without significant change in the absorption band. Even with 5 per cent formalin, the M.L.D./100-gm. rat had increased only from 0·03 to 0·18 mgm. during fifteen days; the absorption band was then affected.

The action of formalin at 55° C. was much more rapid, the M.L.D. increasing from 0·03 to 0·5 mgm./100-gm. rat in 24 hr. with 0·5 per cent formalin, or within 1 hr. with 5 per cent formalin, the characteristic absorption band becoming inflected.

When acetaldehyde (5 per cent) was used instead of the formalin at 55° C., the potency of the toxin decreased from 0·03 to 0·08 mgm./100-gm. rat in 1 hr. without alteration of the absorption band; but after 24 hr. under these conditions, the M.L.D. had increased to 0·5 mgm. and the characteristic absorption band was no longer present.

It appears from the parallelism in the changes in toxicity with the changes in the absorption band produced by various treatments that this absorption band is related to the toxin.

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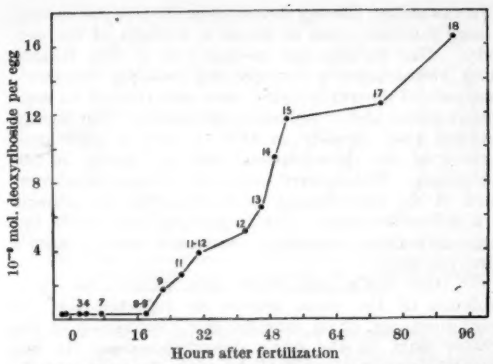
Evidence of Cytoplasmic Deoxyribosides in the Frog's Egg

IT has been pointed out[1] that in the early stages of sea urchin development the amount of deoxynucleic acid per egg found by chemical methods is much in excess of what can be accounted for in the nuclei. Therefore most of the total deoxynucleic acid is likely to be in the cytoplasm.

Deoxynucleic acid has been determined in the ovocytes, mature eggs, and developmental stages of the anuran embryo. The jelly was removed with scissors. The microbiological assay with *Thermobacterium acidophilus R* 26 [2] was used. This method is specific for the deoxyribosidic linkage and allows the determination of less than 1 μgm. of a deoxyriboside. Deoxynucleic acid was determined after depolymerization with Kunitz's deoxynuclease. The amounts of deoxyriboside found, therefore, includes deoxynucleosides, deoxynucleotides and deoxynucleic acid. 1 mol. deoxynucleoside is approximately equivalent to 327 gm. deoxynucleic acid. The accompanying graph shows the results obtained for developing eggs of *Rana platyrrhina* (= *temporaria*). The total amount of deoxyribosides per egg is plotted against hours of development at 13°–17° C. The first two points are valid for unfertilized, mature eggs, in which we found $0{\cdot}20 \times 10^{-9}$ mol. total deoxynucleoside per egg, corresponding to 0·065 μgm. deoxynucleic acid per egg. The numbers above the curve are the Shumway stages of development for *Rana pipiens* (photographs in Rugh[3]). The curve shows that there is no synthesis of deoxyribosides for the first eighteen hours of development. In the late blastula (stage 8–9), when the embryo contains a few thousand cells, synthesis suddenly sets in and continues with decreasing rate throughout gastrulation (stage 8–12). Neurulation (stage 13–15) is accompanied by another increase in deoxyriboside formation. With further development (stage 15–18) there is continued, though slower, synthesis of deoxyribosides.

Just as there is no overall synthesis of purines during the first fifteen to twenty hours of development (for *R. pipiens*[4]), there is no overall synthesis of deoxyriboside linkages, as evidenced by our curve. For the sea urchin embryo the tremendous nuclear multiplication in early life takes place with only slight variations in the amount of deoxynucleic acid per nucleus[5]. Most probably, the same is true for the



Content of deoxynucleic acid in frog's eggs (*Rana platyrrhina*) before and after fertilization. Temp., 13°–17° C. The figures above the curve indicate Shumway stages of development

amphibian embryo, in which there are thousands of nuclei by the time when synthesis of deoxyribosides sets in. These facts pose the problem of the localization of the deoxyribosides of the egg at the time when there is only one or few nuclei in the embryo. O. Hertwig[6] measured the diameter of the female pronucleus in *R. temporaria* and found it to be 35 μ, from which we calculate the nuclear volume to be $2{\cdot}3 \times 10^{-5}$ μl. In this volume the total amount of deoxynucleic acid in the egg, namely, $6{\cdot}5 \times 10^{-5}$ mgm., cannot possibly be located. Cytoplasmic localization of most of the deoxynucleic acid is therefore indicated.

In two experiments we found 11×10^{-9} mgm. and 13×10^{-9} mgm. deoxynucleic acid per spermatozoon of *R. platyrrhina*. Since prior to fusion of male and female pronucleus both have exactly the same volume[6], it is quite likely that the amount of deoxynucleic acid in the egg nucleus is very close to that of the spermatozoon. If so, the amounts of deoxynucleic acid in nucleus and cytoplasm of the mature egg are in the ratio 1 : 5,000. The cytoplasmic store of deoxyribosides should therefore be enough for a few thousands of new diploid nuclei. This is probably enough, or in excess of what is needed, for the first eighteen hours of development, after which new synthesis supplies additional nuclear material for continued nuclear multiplication.

Animal	Date	Sample	Per ovocyte or nucleus	
			Deoxyriboside (mμmol.)	DNA (mμgm.)
R. platyrrhina	30/10/50	25 ovocytes, minus follicle wall	0·30	98
,,	,,	25 ovocytes, minus follicle wall, minus nucleus	0·31	100
,,	,,	25 nuclei	<0·02	<7
,,	,,	50 ovocytes, minus follicle wall	0·27	89
,,	,,	24 nuclei	<0·02	<7
Rana esculenta	15/6/51	20 ovocytes, minus nuclei	1·2	390
,,	,,	18 nuclei	0·05	16
,,	16/6/51	20 ovocytes, minus nuclei	0·80	260
,,	,,	20 nuclei	<0·02	<7
R. platyrrhina	30/4/50	10^4 spermatozoa	0·33	108

In the ovary, the egg develops as an ovocyte having a huge nucleus equal to about a sixtieth of the cell body. This nucleus can be removed in frog Ringer using watchmaker's forceps and braking pipettes[7]. Analyses of deoxyribosides were carried out on separated nuclei and cytoplasms (see table). The results indicate that already in the ovocyte a high proportion of the deoxynucleic acid is located in the cytoplasm. Preliminary evidence is that about one-third of the cytoplasmic deoxyribosides are present in a diffusible state. The remaining two-thirds become diffusible only after treatment with Kunitz's depolymerase.

For the hen's egg (yolk plus white), we have evidence of the same nature as reported for the amphibian egg, of an extranuclear localization of the greater part of the egg's deoxyribosides. It has recently been reported[8] that avidin from the white of the hen's egg is a deoxyribonucleoprotein. It is therefore likely, though not yet certain, that in the hen's egg we have two kinds of extranuclear deoxyribosides, namely, cytoplasmic and egg-white deoxyribosides.

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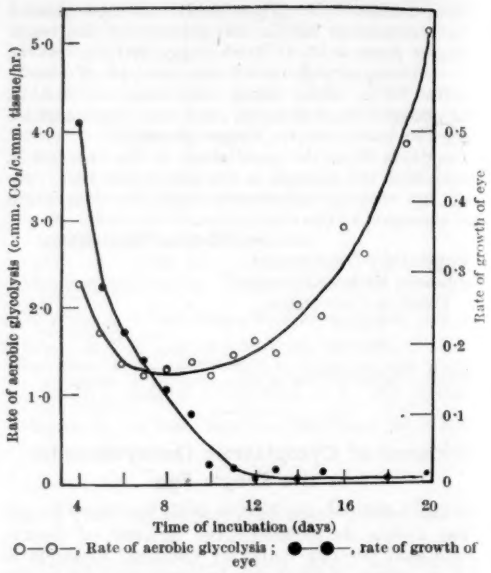
Growth and Aerobic Glycolysis in the Retina of the Chicken Embryo

In the midbrain of the chicken embryo a close relationship has been demonstrated between aerobic glycolysis and cell division[1], from which it can be inferred that growth is dependent on aerobic glycolysis. The rate of aerobic glycolysis has been measured in the retina of the chicken embryo by similar methods and the daily averages plotted (see accompanying graph). The rate of growth of the retina has not been measured directly, but the assumption has been made that it is approximately equal to the rate of growth of the eye. This has been measured in terms of its diameter, the rate of growth on any one day being expressed as the difference in the logarithmic value (in mm. to the base 10) on that day and the day preceding. Rates of growth so determined are plotted in the graph.

Until the eighth day of incubation, the rate of growth of the eye (and, it is assumed, of the retina) decreases similarly to the rate of aerobic glycolysis, suggesting the relationship found in the midbrain. This relationship does not hold after the eighth day, as there is a rise in the rate of aerobic glycolysis not associated with a rise in the rate of growth. These results suggest that the relationship between aerobic glycolysis and morphogenesis is different at the earlier and later stages of incubation. It is possible that such differences may be due to aerobic glycolysis



proceeding by more than one metabolic path, as has been suggested by its response to radiation in the adult retina[2].

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Influence of Crushing on the *p*H of Grass Silage

Silage of good quality has a *p*H of 4·2 or less, with the possible exception of silage made from wilted materials. If grass with a high protein content is ensiled, acids or carbohydrates may have to be added to obtain such a low *p*H. It seems, however, that merely crushing the grass also has the effect of lowering the *p*H. Gneist[1] probably was the first who noticed that crushing resulted in lower losses of nitrogen-free extractives and digestible protein. He ascribed this effect to the inactivation of enzymes. Crasemann and Heinzl[2] found that the formation of lactic acid was speeded up by crushing. Watson[3] is of the same opinion, and thinks that it might be possible to make good silage merely by crushing.

In the course of laboratory experiments on the ensilage of grass with potato pulp, we noticed that if the grass was crushed a much lower *p*H was attained. In our experiments the grass was crushed, or rather ground, by passing it three times through a small roller mill. Fresh and crushed grass were kept in preserving jars at a temperature of 24° C. After fourteen days the *p*H of the juice pressed from the silage was determined using a glass electrode. The accompanying table summarizes the results of our experiments. Crushing clearly results in better silage; but a *p*H of 4·2 was not always attained. In practice it would, of course, be impossible to grind the grass as thoroughly as we did, but if the grass was merely bruised a favourable effect was still

Exp. No.	Composition of the grass		pH after 14 days	
	Dry matter (per cent)	Crude protein in dry matter (per cent)	Without crushing	After crushing
1	14·6	28·1	6·7	5·0
2	14·6	21·9	5·2	4·8
3	17·9	17·3	5·0	3·6
4	19·3	22·7	4·6	3·9
5	17·3	19·8	5·4	3·9

noticed; for example, in experiment No. 5 the *p*H still reached a value of 4·3 if the grass was passed only once through the mill.

We do not think it is likely that the inactivation of enzymes is responsible for the beneficial effect of crushing, as suggested by Gneist (*l.c.*). It is generally known that the stems of grass have a higher carbohydrate content than the leaves and a lower protein content, so it might well be that the distribution of the contents of the stems through the silage explains to a certain extent the effect of crushing.

From our results a relation between dry matter content and *p*H can be noticed, especially after crushing. The same was found earlier by Brouwer[4]. This might be explained by assuming that there is a relation between the dry-matter content and the carbohydrate content of grass.

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Spurious Mitotic Spindles and Fusion Tubes in Bacteria

A SERIES of papers has recently been read by E. D. DeLamater, of the University of Pennsylvania, and his associates, notably at the Sixteenth Cold Spring Harbor Symposium in June 1951, which I was privileged to attend.

By use of a technique which includes acid hydrolysis, staining with thionin, and dehydrating in freezing alcohol, DeLamater claims to be able to demonstrate classical mitotic spindles in bacteria. In my opinion, these appearances are grossly misinterpreted, and he is falling into the error, unfortunately common in the interpretation of cytological structures in bacteria, of mistaking for nuclear material the thickened, secretory areas underlying the cell walls, cross-walls and growing points. These

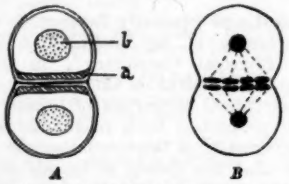

Fig. 1, *A*. Diagram of nuclei and cell envelopes of a large coccus. The cross-wall is secreted by septa from the cell membrane (*a*), which stain well because of their high nucleic acid content. The nuclei (*b*) occupy the centres of the cells. The cell wall and cross-wall do not stain well with 'nuclear' dyes. *B*. DeLamater's interpretation. The cross-wall is not observed; the nuclei are regarded as "centrosomes", the septa as "chromosomes"; the "spindle" is subjective

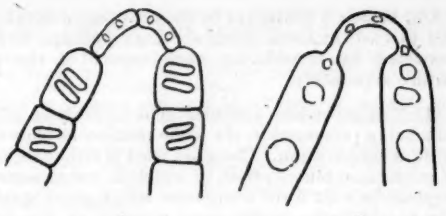

Fig. 2. *A*, Shrunken bacilli joining members of a chain, in *Bacillus*. *B*, DeLamater's interpretation. The cross-walls are not seen and the small bacilli regarded as fusion tubes, their nuclei as migrating nuclear material from their larger neighbours

structures, which are derived from the cell membrane, have a high nucleic acid content[1,2]. Despite DeLamater's contention that his staining technique is specific for nuclear structures, it is my experience that it stains these membranous structures as well as, or rather better than, it does the nuclei. Comparison of preparations fixed by DeLamater's freezing technique, and of others unfixed and mounted in water, shows considerable shrinkage and distortion in the former.

This error is particularly obvious in DeLamater's interpretation of the cytological structures in a large coccus. Cocci of this type are almost invariably divided into two cells by a cross-wall[3], which does not stain well by 'nuclear' dyes. This wall is secreted by a thick septum (*a* in Fig. 1,*A*), which stains well because of its nucleic acid content. The nuclear bodies (*b* in Fig. 1,*A*) lie in the centres of the cells. DeLamater describes the shrunken nuclei as "centrosomes", and the septum material as "chromosomes". The "spindle-fibres" are entirely subjective (Fig. 1,*B*).

These interpretations are made possible only by DeLamater's acknowledged unawareness of the multicellularity of these bacteria[1,4,5], which he describes as multinucleate cells.

Errors arising in this manner have been so common in the past that it was considered worth while to include a warning paragraph in the section dealing with the technique and cytochemistry in my recent monograph upon bacterial cytology[4], but apparently without avail.

The further claim by DeLamater and his associates to describe "fusion tubes" joining individual bacilli of *B. megatherium* is, in my opinion, equally baseless (Fig. 2). These bacilli occur in chains, and it is frequently seen that small, shrunken bacilli retain their position, joined at each end to their neighbours. This is especially frequent under adverse conditions, and it is notable that DeLamater observes these appearances only when the organism is cultured upon blood-agar, which is a most unusual medium for a saprophytic *Bacillus*. Again, the error of considering these structures to be tubes, continuous with the interior of the cells with which they are in contact, arises from unfamiliarity with the behaviour of the bacterial cell wall.

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Dr. Bisset's criticisms of the techniques developed and utilized in these studies[1-3] may perhaps best be answered by considering each aspect of the procedure separately.

(1) The procedure includes acid hydrolysis of the cells being processed in the same manner as that used in the Feulgen stain. The stain used is either thionine or methylene blue *A*, both of which in the presence of sulphurous acid form complexes which react specifically to aldehydes in the same manner as the Schiff reagent, except that no leucobase is formed by the dye in the presence of sulphurous acid. In the case of thionine, by carefully balancing the amount of sulphurous acid added, it is possible to obtain a thionine–sulphurous acid complex and still maintain a percentage of unreacted thionine which is capable, in this mixture, of acting as a basic dye and staining other cell elements; in other words, is capable of acting as a counter-stain. It is because of the excess of this thionine that it has been possible to stain elements within the nucleus other than the chromosomes, such as the centrioles and the spindles. Similar results can be obtained by counter-staining Feulgen or azure *A*-SO_2 stained preparations with fast green.

(2) The dehydration procedure utilized involves the instantaneous freezing of the preparations in absolute alcohol at temperatures below — 50° C. Under these conditions no distortion of the cell occurs, due either to collapse of internal structure or by the formation of large ice crystals. Freezing-dehydration techniques, utilizing vacuum apparatus, have long been used in critical cytologic work. In the present procedure the water is removed from the cell in the frozen state directly into solution in the alcohol, and as this proceeds the cell is hardened by the alcohol. Cytochemically, it seems unlikely that these procedures should be subject to criticism.

As for the errors of interpretation which Dr. Bisset is ascribing to us, it seems proper that the evidence should be presented so that the photographs, which are included with the original papers, may speak for themselves. Reference should be made to these photographs by those interested. It might well be that if the criticizer were to apply himself diligently to the methods which he criticizes, and were to compare these new procedures with the older techniques which he uses, he, too, might be convinced of their superiority. Students at the Cold Spring Harbor Summer Session, 1951, under the direction of myself and a qualified assistant, produced entirely acceptable preparations when the procedure was followed in detail.

Concerning the criticism of the mitotic process as described in cocci, it should be pointed out that the nuclear activity as described by myself[4] is distinct from cross-wall formation, which has been demonstrated to occur by means of a cell plate in cocci, as in the onion root tip. If the structures which Dr. Bisset considers to be subjective are actually subjective, it is remarkable that it is possible to photograph them. It should be pointed out further in connexion with the cocci that, on the basis of the techniques used, I consider cocci to be unicellular organisms, and each cell to be uninucleate.

Dr. Bisset is in error when he states that the interpretations which my associates and I[5,6] have presented are errors common to the past, because only two examples occur in the literature to our knowledge in which mitosis has been specifically described in bacteria. The first of these, by Vedjovsky[7], has been criticized, not because of its validity in terms of observation, but because the organism that Vedjovsky studied was probably not a bacterium, but a protozoon. The second and more recent work by Chance[8], using special techniques, gives what appears to be an unequivocal demonstration of mitotic spindles in bacteria. The reader might also refer to Fig. 21, left, of Bisset's recent book[9] for a passable example of a mitotic spindle in a bacterium.

Finally, Dr. Bisset considers the observations presented for the occurrence of fusion tubes in *Bacillus megatherium* to be, in his opinion, "equally baseless". He considers that the conditions under which such fusions are observed to occur are abnormal for this organism. It is perhaps worth while to emphasize that the factor which apparently induces this condition occurs in a sub-fraction of Cohn's Fraction 3 of human serum as well as in casein, and that Braun has similarly demonstrated the re-direction of biochemical pathways by similar blood fractions in other organisms. In addition, it should be pointed out that the work of Hawker[10] and Buston and Basu[11] in Britain, and the work of Cantino[12] in the United States, indicate that sugar metabolism related to the occurrence, growth and sexual reproduction in certain fungi involves complex biochemical problems which are just beginning to be evaluated. The present work on *Bacillus megatherium* tends to concur with such studies of Hawker and others, and it might be better for Dr. Bisset to allow the evidence to accumulate and be evaluated before it is condemned.

Edward D. DeLamater

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University of Pennsylvania.

[1] DeLamater, E. D., Cold Spring Harbor Symposia on Quantitative Biology, **16** (1952).
[2] Blank, H., McCarthy, P. L., and DeLamater, E. D., *Stain Tech.*, **26**, 193 (1951).
[3] DeLamater, E. D., *Stain Tech.*, **26**, 199 (1951).
[4] DeLamater, E. D., *Bull. Torrey Bot. Club* (1951) (in the press).
[5] DeLamater, E. D., and Hunter, M. E., *Amer. J. Bot.*, **38**, 659 (1951).
[6] DeLamater, E. D., and Mudd, S., *Exp. Cell Res.*, **2**, 499 (1951).
[7] Vedjovsky, F., *Centralbl. Bakt. Parasitent.* II Abt., Allgemeine, **6**, 577 (1900); **11**, 481 (1904).
[8] Chance, H. L., *J. Bact.*, **35**, 347 (1938).
[9] Bisset, K. A., "The Cytology and Life-History of Bacteria" (Williams and Wilkins Co., Baltimore, Md., 1950).
[10] Hawker, L. E., *Ann. Bot.*, **11**, 245 (1947).
[11] Buston, H. W., and Basu, S. N., *J. Gen. Microbiol.*, **2**, 162 (1948).
[12] Cantino, E., *Amer. J. Bot.*, **38**, 579 (1951).

"The Liquid State"

The informed and generally favourable review of the second volume of my book, "An Advanced Treatise on Physical Chemistry", in *Nature* of January 12, p. 46, remarks on the absence of a treatment of the electrical properties of liquids. Optical and electrical properties both of liquids and solids have been deferred to a later volume. It may also be mentioned that the theory of liquids is taken up in relation to properties in parts of the book other than the first section, which might not be clear from the review.

J. R. Partington

29 Mill Road,
Cambridge.

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, February 11

ROYAL GEOGRAPHICAL SOCIETY (at 1 Kensington Gore, London, S.W.7), at 5 p.m.—Brigadier G. F. Heaney: "Survey of India since World War II".

Tuesday, February 12

BRITISH PSYCHOLOGICAL SOCIETY, INDUSTRIAL SECTION (in Room 105, London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 1 p.m.—Mr. B. D. Misselbrook: "The Functions and Responsibilities of the Psychologist in Industry".

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 1.15 p.m.—Mr. P. R. Bell: "A Botanist in the Andes".*

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS (at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2), at 5 p.m.—Mr. J. A. Lawrence: "Some Applications of Cold Cathode Tubes in Switching Circuits".

ZOOLOGICAL SOCIETY OF LONDON (at the Zoological Gardens, Regent's Park, London, N.W.8), at 5 p.m.—Scientific Papers.

INSTITUTION OF CHEMICAL ENGINEERS (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Mr. K. A. Fern: "Operation of the Dutch State Mines Cyclone as a Separator of Minerals".

ROYAL SOCIETY OF MEDICINE, EXPERIMENTAL MEDICINE SECTION (at 1 Wimpole Street, London, W.1), at 5.30 p.m.—Discussion on "Agricultural Poisons".

INSTITUTION OF ELECTRICAL ENGINEERS (at Central Hall, Westminster, London, S.W.1), at 6.30 p.m.—Dr. G. F. Dutton: "Sound Recording—Home, Professional, Industrial and Scientific Applications" (Faraday Lecture). (Admission by ticket obtainable from the Institution.)

SHEFFIELD METALLURGICAL ASSOCIATION (joint meeting with the ROYAL INSTITUTE OF CHEMISTRY, in the Grand Hotel, Sheffield), at 7 p.m.—Sir Charles Goodeve, F.R.S.: "Physical Chemistry of Steelmaking".

SOCIETY OF INSTRUMENT TECHNOLOGY, NORTH-WEST SECTION (at the College of Technology, Manchester), at 7.30 p.m.—Dr. L. Hartshorn: "Fundamentals of Electrical Measurement".

Wednesday, February 13

INSTITUTE OF PETROLEUM (at Manson House, 26 Portland Place, London, W.1), at 2.30 p.m.—Symposium on "The Lubrication of Gears and the Testing of Gear Lubricants" (arranged by Dr. C. G. Williams).

ROYAL SANITARY INSTITUTE (at 90 Buckingham Palace Road, London, S.W.1), at 2.30 p.m.—Discussion on "Port Health Control" (to be opened by Mr. H. C. Maurice Williams).

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Dr. J. D. McGee: "Television Technique as an Aid to Observation".

PHYSICAL SOCIETY, COLOUR GROUP (in the Lecture Theatre, Institute of Ophthalmology, Judd Street, London, W.C.1), at 3.30 p.m.—Dr. G. W. Granger: "An Experimental Study of Colour Preferences".

SOCIETY OF CHEMICAL INDUSTRY, FOOD AND MICROBIOLOGY GROUPS (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.30 p.m.—Dr. E. R. Hiscox and Mrs. E. D. Cookson: "The Effect of Reworking and Blending on the Bacteriological Flora of Butter".

Thursday, February 14

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Mr. J. A. W. Huggill: "The Flow of Gases through Capillaries"; Mr. J. B. Hasted: "Inelastic Collisions between Ions and Atoms".

LONDON MATHEMATICAL SOCIETY (at the Royal Astronomical Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Dr. J. C. P. Miller: "Polynomial Interpolation".

ILLUMINATING ENGINEERING SOCIETY, MANCHESTER CENTRE (in the North Western Electricity Board Demonstration Theatre, Town Hall Extension, Manchester), at 6 p.m.—Mr. H. C. Weston: "Lighting and Vision in Advancing Age".

BRITISH INSTITUTION OF RADIO ENGINEERS, SCOTTISH SECTION (in the Department of Natural Philosophy, The University, Drummond Street, Edinburgh), at 7 p.m.—Prof. G. W. O. Howe: The Clerk-Maxwell Memorial Lecture.

OIL AND COLOUR CHEMISTS' ASSOCIATION, LONDON SECTION (at Manson House, 26 Portland Place, London, W.1), at 7 p.m.—Dr. W. Hughes: "The Physical Characteristics of Titanium Pigments".*

Friday, February 15

EUGENICS SOCIETY (at Manson House, 26 Portland Place, London, W.1), at 5 p.m.—Dr. J. A. Fraser Roberts: "The Genetics of Mental Deficiency" (Galton Lecture).*

ROYAL INSTITUTE OF PHILOSOPHY (at University Hall, 14 Gordon Square, London, W.C.1), at 5.15 p.m.—Prof. H. B. Acton: "Philosophy and Social Science".*

INSTITUTION OF MECHANICAL ENGINEERS (in conjunction with the INDUSTRIAL ADMINISTRATION AND ENGINEERING PRODUCTION GROUP, at Storey's Gate, St. James's Park, London, S.W.1), at 5.30 p.m.—Mr. T. F. O'Connor: "The Allocation of Machines to Operators".

UNIVERSITY OF LONDON (in the Physiology Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. F. Bergel: "Some Recent British Contributions in the Field of Pharmaco-Therapeutics".* (Further Lecture on February 22.)

MANCHESTER STATISTICAL SOCIETY, INDUSTRIAL STUDY GROUP (at the Albert Hall, Peter Street, Manchester), at 6.45 p.m.—Mr. E. Packer: "Control Testing in Textiles".

INSTITUTE OF PHYSICS, MANCHESTER AND DISTRICT BRANCH (in the New Physics Theatre, The University, Manchester), at 7 p.m.—Dr. J. D. Craggs: "Counting Methods".

SOCIETY OF CHEMICAL INDUSTRY, FINE CHEMICALS GROUP (in the Chemistry Lecture Theatre, King's College, Strand, London, W.C.2), at 7 p.m.—Scientific Papers.

SOCIETY OF CHEMICAL INDUSTRY, LONDON SECTION (joint meeting with the LONDON AND SOUTH-EASTERN COUNTIES SECTION of the ROYAL INSTITUTE OF CHEMISTRY, at the Technical College, Brighton), at 7 p.m.—Dr. W. L. Bedwell: "The Production of Sulphuric Acid from Calcium Sulphate".

UNIVERSITY OF LONDON (at Royal Holloway College, Englefield Green, Surrey), at 8.15 p.m.—Mr. L. J. F. Brimble: "Science and the Press".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Prof. G. Temple, F.R.S.: "The New World of Aerodynamics".

Saturday, February 16

BIOCHEMICAL SOCIETY (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 11 a.m.—Symposium on "Lipid Metabolism".

LONDON COUNTY COUNCIL (at the Horniman Museum, London Road, Forest Hill, London, S.E.23), at 3.30 p.m.—Mr. E. A. Lane: "The Mediaeval Pottery of Persia and the Near East".*

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

CHEMISTS (Scientist II or Scientist III grade) for analytical investigational work in the Coal Survey Laboratories at Chester and Newcastle-upon-Tyne—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, stating post applied for and quoting TT/416 (February 16).

LECTURER IN PHYSICS, and an ASSISTANT (Grade B) IN ZOOLOGY—The Registrar, Nottingham and District Technical College, Shakespeare Street, Nottingham (February 18).

LECTURER IN PHILOSOPHY at the University of Melbourne—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (February 22).

LECTURER or SENIOR LECTURER IN ENGINEERING WORKSHOP PRACTICE, and a SENIOR LECTURER IN ELECTRICAL ENGINEERING, at Kumasi College of Technology, Gold Coast—The Secretary, Advisory Committee on Colonial Colleges, 15 Victoria Street, London, S.W.1 (February 23).

PRINCIPAL SCIENTIFIC OFFICER (with a first- or second-class honours degree, or equivalent qualification, in mathematics or a scientific subject, and good research experience, preferably including the use of strain gauges and other forms of precise extensometers) IN THE METROLOGY DIVISION of the National Physical Laboratory—The Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting S.4121/52 (February 28).

ASSISTANT OR ASSISTANT LECTURER IN THE DEPARTMENT OF PSYCHOLOGY—The Secretary, Bedford College for Women, Regent's Park, London, N.W.1 (February 29).

ASSISTANT LECTURER (Grade B) to teach CHEMISTRY, PHYSICS and MICROBIOLOGY in the National College of Food Technology, Eagle Court, London, E.C.1—The Secretary, (F.E. Branch IIIA), Ministry of Education, Curzon Street, London, W.1 (February 29).

ASSOCIATE PROFESSOR IN FOOD TECHNOLOGY in the School of Chemical Engineering in the New South Wales University of Technology—The Agent-General for New South Wales, 56 Strand, London, W.C.2 (February 29).

ASSOCIATE PROFESSORSHIPS IN ORGANIC CHEMISTRY, and IN INORGANIC CHEMISTRY, in the School of Applied Chemistry in the New South Wales University of Technology, Sydney—The Agent-General for New South Wales, 56 Strand, London, W.C.2 (February 29).

PRINCIPAL OF THE DERBY TECHNICAL COLLEGE—The Director of Education, Education Office, Becket Street, Derby (February 29).

PROFESSOR OF CHEMISTRY in the Faculty of Technology of the University of Manchester and in the College of Technology—The Registrar, College of Technology, Manchester 1 (February 29).

NUFFIELD FOUNDATION FELLOWSHIPS AND SCHOLARSHIPS IN DENTISTRY—The Secretary, Nuffield Foundation, 12–13 Mecklenburgh Square, London, W.C.1 (Fellowships, March 1; Scholarships, June 30).

QUICK PROFESSORSHIP OF BIOLOGY—The Registrary, The Old Schools, Cambridge (March 1).

SCIENTIST (with a good honours degree in science, or equivalent qualification, preferably with a sound background in geology) in the Coal Survey Laboratory at Leeds—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, endorsed TT/423 (March 1).

SENIOR RESEARCH OFFICER (with university honours degree in science, with physical chemistry or physics as a major subject, or equivalent qualifications, and several years research experience) to investigate the function of carbon black in rubber compounding, with a view to finding substitutes of Australian origin (Ref. No. 3691), and a RESEARCH OFFICER (with university honours degree in science with physical chemistry as a major subject, or equivalent qualifications, with research experience preferably, but not necessarily, in the theory of electrolytes or polymers) to investigate the properties of solutions of polyelectrolytes (Ref. No. 3692); in the Physical Chemistry Section of the Division of Industrial Chemistry, Fishermen's Bend, Melbourne—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting the appropriate Ref. No. (March 1).

CHAIR OF MEDICAL PROTOZOOLOGY at the London School of Hygiene and Tropical Medicine—The Academic Registrar, University of London, Senate House, London, W.C.1 (March 3).

SENIOR LECTURERS IN ANIMAL HUSBANDRY, CIVIL ENGINEERING (2) and PHARMACOLOGY; and LECTURERS IN AGRICULTURAL BOTANY, CIVIL ENGINEERING (3), MECHANICAL ENGINEERING (4), ELECTRICAL ENGINEERING (2 in Power Engineering and 1 in Electronics), GEOGRAPHY (Physical Geography), VETERINARY ANATOMY, and VETERINARY SURGERY AND OBSTETRICS; at the University of Sydney—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (March 3).

LECTURER IN ASTRONOMY—The Secretary, The University, Aberdeen (March 8).

LECTURER IN SOCIAL ANTHROPOLOGY—The Registrar, The University, Manchester 13 (March 17).

ASSISTANT LECTURER IN THE DEPARTMENT OF GEOLOGY—The Registrar, University of Otago, Dunedin, New Zealand (March 31).

POSTGRADUATE STUDENTSHIPS IN FISHERIES, SOIL SCIENCE, AGRICULTURE, ECOLOGY, STORED PRODUCTS ENTOMOLOGY, INSECTICIDES, FUNGICIDES AND HERBICIDES, and VETERINARY SCIENCE—The Under-Secretary of State, Colonial Office (Research Department), S.610, Sanctuary Buildings, Great Smith Street, London, S.W.1 (March 31).

DEWAR RESEARCH FELLOWSHIP IN RADIOCHEMISTRY—The Secretary, The University, Edinburgh (April 30).

ASSISTANT (medically qualified, preferably with experience of bacteriology) IN THE BACTERIOLOGY DEPARTMENT, for teaching and research—The Secretary, University College Hospital Medical School, University Street, London, W.C.1.

CHEMICAL ENGINEER (with a good honours degree and with experience in the development of chemical processes from the laboratory to the commercial scale) to work on the development of processes for the extraction of the newer algal chemicals—The Secretary, Institute of Seaweed Research, Inveresk, Midlothian.

ENTOMOLOGIST, Desert Locust Survey under the East Africa High Commission—The Under-Secretary of State, Colonial Office, Research Department, Sanctuary Buildings, Great Smith Street, London, S.W.1.

EXPERIMENTAL OFFICERS (highly skilled in experimental bacteriology, biochemistry or biophysics) at a Ministry of Supply Research Establishment near Salisbury—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting G.19/52A.

GEOLOGISTS (with good honours degree in geology, with research and field experience) in the Public Works Department, Geological Survey, Sudan Government—The Sudan Agent in London, Wellington House, Buckingham Gate, London, S.W.1, quoting Geologist 4/161.

GRADUATE IN PHYSICS or PHYSICAL CHEMISTRY (experience in the handling of isotopes and of counting techniques, and some knowledge of biochemistry would be advantageous in the work involved) in the Division of Biophysics and Optics—The Director, National Institute for Medical Research, Mill Hill, London, N.W.7.

PRINCIPAL METALLURGIST to organize and direct teams engaged on large-scale development work at Springfields Factory, Salwick, and a PRINCIPAL METALLURGIST at Risley, to advise on the metallurgical aspect of plant design for the production of atomic energy, etc.—The Ministry of Supply, Division of Atomic Energy (Production), Risley, Warrington, Lancs., stating post applied for and quoting Ref. 292.

RESEARCH OFFICER (with honours degree) and a RESEARCH ASSISTANT (with Higher National Certificate, or equivalent), to specialize in the study of, and construction of equipment for measuring, noise in vehicles—The Director, Motor Industry Research Association, Great West Road, Brentford, Middx.

SCIENTIFIC OFFICER (with a first- or second-class honours degree in natural science or equivalent qualifications, and experience in freshwater biology) as FRESHWATER BIOLOGIST, to carry out research on schistosomiasis in the Gezira area or elsewhere in the Sudan, and to train Sudanese assistants, medical and zoological, in the technique of investigation into schistosomiasis—The Sudan Agent in London, Wellington House, Buckingham Gate, London, S.W.1, quoting 'Freshwater Biologist 4/1206'.

SENIOR SCIENTIFIC OFFICER to join team investigating fatigue problems of large-scale welded structures and pressure vessels in new laboratories at Abington, Cambridge—The Director of Research, British Welding Research Association, 29 Park Crescent, London, W.1.

SENIOR SCIENTIFIC OFFICERS and SCIENTIFIC OFFICERS at Admiralty Experimental Establishments in the vicinity of London, Greenock, Haslemere, Portsmouth, Rosyth and Weymouth: PHYSICISTS (Ref. A.336/50A) capable of undertaking research or development in general physical problems, electronics, acoustics or thermodynamics, ELECTRICAL ENGINEERS (Ref. D.367/50A) qualified to undertake research, development or design in telecommunications, radar, electronics, instrumentation or light electrical mechanisms, MECHANICAL ENGINEERS (Ref. C.631/50A) capable of design, development or research work in light mechanisms, structures or hydrodynamics—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting the appropriate Ref. No.

WELL SUPERINTENDENT (with at least ten years experience in mining or well sinking, and accustomed to the use of mechanical equipment and explosives) to take charge of a well-sinking programme under the supervision of the Drilling Engineer, in the Public Works Department, Sudan Government—The Sudan Agent in London, Wellington House, Buckingham Gate, London, S.W.1, quoting Well Superintendent 4/1814.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Productivity Report. Universities and Industry: Report of a Specialist Team which visited the United States of America in 1951. Pp. viii+29+3 plates. (London and New York: Anglo-American Council on Productivity, 1951.) 2*s.* 6*d.* [2711

Ministry of Food. The Urban Working-Class Household Diet, 1940 to 1949; First Report of the National Food Survey Committee. Pp. vi+114. (London: H.M. Stationery Office, 1951.) 3*s.* 6*d.* net. [2711

Nuffield Provincial Hospitals Trust. Report, 1948–1951. Pp. 68. (London: Nuffield Provincial Hospitals Trust, 1951.) [2711

Scientific Proceedings of the Royal Dublin Society. Vol. 25 (N.S.), No. 19: The Intrinsic Viscosity of Low Molecular Weight Polystyrenes. By D. C. Pepper. Pp. 239–250. 2*s.* Vol. 25 (N.S.), No. 20: The Radioactivity of Potassium 40. By C. F. G. Delaney. Pp. 251–294. 7*s.* (Dublin: Royal Dublin Society, 1951.) [2711

Annual Report for 1950 (No. 63) of the Marine Biological Station at Port Erin, Isle of Man. Drawn up by J. S. Colman. Pp. 32. (Liverpool: University Press of Liverpool, 1951.) 3*s.* [2711

British Museum (Natural History). Expedition to South-West Arabia, 1937–8. Vol. 1, Nos. 16–19: 16. Coleoptera: Haliplidae, Dytiscidae, Gyrinidae, Hydraenidae, Hydrophilidae, by J. Balfour-Browne; 17. Aquatic and Semi-Aquatic Hemiptera, by E. S. Brown; 18. Coleoptera: Coccinellidae, by Dr. A. P. Kapur; 19. Coleoptera: Pselaphidae, by Dr. René Jeannel. Pp. 179–305+plates 10–14. (London: British Museum (Natural History), 1951.). 20*s.* [2711

Welsh Scenery Illustrated and Explained. Pp. 32. (Cardiff: National Museum of Wales, 1951.) 2*s.* 6*d.* [2811

Proceedings of the Royal Irish Academy. Vol. 54, Section B, No. 8: Movements of Salmon around Ireland. By Arthur E. J. Went. Pp. 169–201. (Dublin: Hodges, Figgis and Co., Ltd., 1951.) 7*s.* 6*d.* [2911

Overseas Food Corporation. Annual Report and Statement of Accounts for the Year ended 31st March, 1951. Pp. iv+82. (London: H.M. Stationery Office, 1951.) 3*s.* net. [2911

Department of Scientific and Industrial Research: Road Research Laboratory. Road Note No. 12: Gritting Machines for Surface Dressing. By D. B. Waters and D. S. Wilson. Pp. 14+7 plates. (London: H.M. Stationery Office, 1951.) 1*s.* 6*d.* net. [2911

Philosophical Transactions of the Royal Society of London. Series A: Mathematical and Physical Sciences. No. 878, Vol. 244: Measurements of the Variation with Depth of the Main Geomagnetic Field. By S. V. Runcorn, A. C. Benson, A. F. Moore and D. H. Griffiths. Pp. 113–151. (London: Cambridge University Press, 1951.) 10*s.* 6*d.* [2911

British Museum (Natural History). Fossil Mammals of Africa, No. 4: Miocene Anthracotheriidae from East Africa. By D. G. Macinnes. Pp. 24+4 plates. (London: British Museum (Natural History), 1951.) 12*s.* 6*d.* [312

Forestry Commission. Britain's Forests: Loch Ard. Pp. 20. 1*s.* net. Guide to New Forest. Pp. vi+86. 2*s.* 6*d.* net. (London: H.M. Stationery Office, 1951.) [312

Other Countries

Institut Royal Météorologique de Belgique. Mémoires, Vol. 42: Sur la thermodynamique de la condensation dans l'atmosphère. Par L. Dufour. Pp. 40. Mémoires, Vol. 43: Contribution à l'étude des fluides incompressibles en mouvement turbulent. Par Dr. J. Van Isacker. Pp. 48. Mémoires, Vol. 47: Étude de la radiation globale du soleil. Par M. Nicolet et R. Dogniaux. Pp. 50. Mémoires, Vol. 49: Ensoleillement et orientation en Belgique, 4, Rayonnement reçu sur une surface horizontale. Par M. Nicolet et R. Dogniaux. Pp. 12+9 plates. Miscellanées, Fasc. 36: Sur le théorème de la circulation de V. Bjerknes et la théorie des invariants intégraux. Par Dr. Paul Dedecker. Pp. 64. Miscellanées, Fasc. 43: Aperçu sur le climat du littoral belge. Par L. Poncelet. Pp. 24. (Uccle: Institut Royal Météorologique de Belgique, 1951.) [2711

New Zealand. Twenty-fifth Annual Report of the Department of Scientific and Industrial Research. Pp. 80. (Wellington: Government Printer, 1951.) 1*s.* 6*d.* [2811

World Health Organization. Monograph Series No. 6: Cardiolipin Antigens; Preparation and Chemical and Serological Control. By Dr. Mary C. Pangborn, Dr. F. Maltaner, Dr. N. V. Tompkins, Dr. T. Beecher, Dr. W. R. Thompson and Mary Rose Flynn. Pp. 63. (Geneva: World Health Organization: London: H.M. Stationery Office, 1951.) 5*s.*; 1 dollar; 4 Swiss francs. [2811

Sveriges Geologiska Undersökning. Ser. C, No. 503 (Årsbok 43, 1949, No. 1): Spår av Varangeristiden i Norrbotten. Av Oscar Kulling. Pp. 44. 2 kr. Ser. C, No. 515 (Årsbok 44, 1950, No. 1): Geology of the Sulphide Deposits at Mensträsk and a Comparison with other Deposits in the Skellefte District. By Erland Grip. Pp. 52+4 plates. 4 kr. Ser. C, No. 516 (Årsbok 44, 1950, No. 2): Manganese Mineralization in the Ultevis District, Jokkmokk, North Sweden, Part 2, Mineralogical Notes. By Olof H. Ödman. Pp. 28. 1 kr. Ser. C, No. 517 (Årsbok 44, 1950, No. 3): Kosteröarna, ett nyckelområde för västra Sveriges prekambriska geologi. Av Bror Asklund. Pp. 56+2 plates. 4 kr. (Stockholm: P. A. Norstedt and Söner, 1951.) [2911

Indian Forest Records (New Series). Botany, Vol. 4, No. 3: New or Noteworthy Plants from the Upper Gangetic Plain. By M. B. Raizada. Pp. ii+65–72+4 plates. (Delhi: Manager of Publications, 1951.) 9 annas; 10*d.* [2911

Drought Feeding of Sheep: the Value of Weekly Feeding. Pp. 12. (Melbourne: Commonwealth Scientific and Industrial Research Organization, 1951.) [312

Race and Biology. By Prof. L. C. Dunn. (Race Question in Modern Science Series.) Pp. 48. (Paris: Unesco; London: H.M. Stationery Office, 1951.) 1*s.* 6*d.*; 25 cents; 75 francs. [312

Publications de l'Institut National pour l'Étude Agronomique du Congo Belge. Série Technique No. 40: Matériaux pour l'étude de l'économie rurale des populations de la Cuvette forestière du Congo Belge. Par Prof. A.-G. Baptist. Pp. 64. (Bruxelles: Institut National pour l'Étude Agronomique du Congo Belge, 1951.) 50 francs. [312

Annual Report of the Trustees of the Museum of Applied Arts and Sciences for the Year ended 31st December, 1950. Pp. 13. (Sydney: Government Printer, 1951.) [512

Biologia: an International Year-Book devoted to the Pure and Applied Plant and Animal Sciences. Vol. 2 (1950–51). (Chronica Botanica, Vol. 12, No. 4–6.) Pp. 109–332. (Waltham, Mass.: Chronica Botanica Co.; London: H. K. Lewis and Co., Ltd., 1951.) [512